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ABSTRACT

The monograph presents the findings of a decade long research project on the cognitive learning of children. Several other areas of general significance involved in the work are also treated. These include: (1) the importance of the work to the development of basic learning theory; (2) certain developments in methodology and in a philosophy of experimental methodology; (3) inclusion of theories of the aspects of cognitive development dealt with, e.g. Piaget; and (4) general implications for a conception of child development through learning. Recognition of the need to use the basic principles and methods of experimental psychology to study representative samples of human behavior led to the execution of the studies presented in the monograph. The four extensively described are: (1) Alphabet Reading; (2) Learning Reading Units and Classical Concept Formation; (3) Counting Learning and Counting Learning Mediated by Verbal Response Chains; and (4) Writing Learning, Imitation, and the Cognitive Learning Acceleration. (TL)

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LEARNING AND COGNITIVE DEVELOPMENT: REPRESENTATIVE SAMPLES (READING, NUMBER CONCEPTS, WRITING) AND EXPERIMENTAL-LONGITUDINAL METHODS

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Final Report of Child Learning Project

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LEARNING AND COGNITIVE DEVELOPMENT: REPRESENTATIVE SAMPLES (READING, NUMBER CONCEPTS, WRITING) AND EXPERIMENTAL-LONGITUDINAL METHODS[1]

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GENERAL INTRODUCTION

The purpose of the present monograph is to report some of the findings of a long-extended research project on the cognitive learning of children. Although the focus is upon the research findings, especially those of the latter stages of development of the project, several other areas of general significance have been involved in the work. That is, the work has been conducted for its significance to the development of basic learning theory. The work also involves certain developments in methodology and in a philosophy of experimental methodology; it contains theories of the aspects of cognitive development dealt with; and it has more general implications for a conception of child development through learning. Some of these more general points may be usefully touched upon in this introduction.

The Need for Representative Samples of Behavior

When a study employs a particular set of subjects, it is well recognized that the subjects are a sample of some population or universe. This is true, at least if the study has been done properly, since no one is interested solely in how a particular set of subjects will react to the experimental condition. Frequently, however, it is not explicitly understood that the same holds true of the other elements of an experiment, such as the stimulus circumstance manipulated (the experimental variable), as well as the dependent condition of the behavior (the experimental task). Thus, for example, the experimental task employed must also be considered to sample some universe of behaviors--if one is to generalize the results to other than the specific experimental situation.

Actually, if this was not assumed, it would make no sense to study learning principles in the context of a child pulling a knob, not to mention a rat pressing a lever. Few of us are strongly invested in ascertaining the conditions that affect the child's knob-pulling. We are interested only because, at least on an implicit level, we feel that the general conditions that affect knob-pulling will also affect any instrumental response. Many people concerned with significant, functional, human behaviors will not even read a study involving a simple behavior--so convinced are they that it is meaningless for understanding significant, functional, human behavior. This is to say that they do not believe that a simple response comes from the same universe as the functional, complex responses in which they are interested.

And this skepticism is certainly quite justified. A principle of learning, for example, that had been shown only with one particular instrumental behavior would not convince us that the principle would generalize to all instrumental behaviors, or even a large number of them. However, as the principle was demonstrated to hold in the context of additional instrumental behaviors, confidence in the validity of the principle for the universe of instrumental behaviors would be increased.

The problem with many individuals interested in significant, functional human behaviors, however, is that they do not employ the same sampling logic in other cases where it is equally relevant. That is, many people who would be disinterested in a study involving knob-pulling responses will nevertheless be interested in a study which in name deals with significant, functional, behaviors. This interest can occur even when there is no real justification for considering the experimental task actually to be a sample of the universe of behaviors that are commonly given that name. As an example, take a study of problem solving where the subject has the task of tying two strings together that cannot be reached by hand (the Maier two-string problem). We must ask whether such a task is a sample of the universe of behaviors called problem solving in human behavior. This would include the problem solving that we see in everyday life and in science. The same is true when a study is conducted on verbal learning, concept formation, or memory, employing paired-associates learning of nonsense syllables. Can we generalize to the universe of verbal learning tasks or memory tasks with which we are actually concerned? For example, does a principle demonstrated with the short-term paired associate task that lasts an hour or so generalize to verbal learning tasks that involve many, many items and that require thousands of learning trials and months of time? Can we make statements concerning how the principles found in the short-term experimental study of verbal learning generalize to a real sample of verbal learning, such as in reading acquisition, the acquisition of addition and multiplication tables, the acquisition of a second language, and so on? Can we make such statements concerning how concept-formation principles in the brief experimental tasks commonly used extend to the manner in which the child acquires a concept of number, of color, of size, and so on? If the experimental task is a sample of some universe of behavioral skills, we would expect the principles found with the sample to generalize to the universe.

The fact is, of course, that most of the experimental tasks that are popularly employed have never been related to a universe of actual behaviors. It is accepted that if there is some gross resemblance of the experimental task to some common-sense description of behavior labeled by a particular term, then the experimental task may be given that name, and the results presumably refer to that type of behavior--whatever it is.

It may be suggested that one of the reasons for sterility in areas of psychology results from the fact that samples of behavior are employed in the experimental tasks about which we know very little. In many cases we do not know what the universe of behaviors in which we are interested is--be it verbal learning, concept formation and function, identification, socialization, intelligence, or what have you. Moreover, the experimental tasks employed have little status as samples of some universe of behaviors. They are selected to have some face validity, but mostly because they are experimentally feasible. For example, the task is selected to be brief, because if the task is long, the time spent in conducting an experiment will be exorbitant. Moreover, when working with children, if the task is long, repetitive, and demanding of close attention, one cannot readily obtain subjects with whom to conduct the experiment and maintain their participation. The task must also be one that the subjects, at least in large part, can handle fairly readily--one cannot within acceptable expenditure train the subjects if large groups are to be employed. In addition, the task must also yield consistent data to the manipulation of independent variables. Developing such tasks has certainly been seen as one line of progress in psychology. The experimental nature of the field is so strong that once an experimental task has shown that it will produce consistent data, and once it becomes generally accepted, it will be employed in large numbers of studies--especially if on face value it appears to be like some significant, functional human behavior. This will occur however, even in the absence of further information concerning the representative nature of the task or of the character of the universe of behavior.

Thus, the fact that an experimental task yields consistent data as a result of experimental manipulations is by no means a guarantee that the task is actually a sample of some universe of important behaviors. There are many cases where experimental tasks have been used in hundreds of studies and produced consistent results from the manipulation of independent variables--only to have produced no other progress toward understanding the human behavior in which people were really interested. Verbal learning, concept formation, problem solving, and other examples of complex human behavior have been cited as areas of study that have produced many, many studies without bringing us closer to an understanding of the universes of actual behavior referred to by these terms (Staats, 1966, 1968_a_, 1968_d_). It is interesting to note that the sterility of such research is beginning to be recognized by others. James Deese, who himself has done much paired-associate verbal learning research, has reached the following conclusion:

> In the study of the higher mental processes, despite nearly a century of investigation, the results have been little more than a long history of doubt, frustration, and trivial generalities. Despite the existence of an embarrassingly large number of experiments in which rote learning of some materials has been controlled and varied in time of exposure or trials, we still do not know whether there is some link between number of exposures and how well people learn . . . . That the experimental psychology of rote learning has been unable to solve so simple and elementary a problem should lead us to question whether or not we are going about things in the right way (Deese, 1969, p. 517).

Deese retreats in his total rejection of behavioral experimentation to an embrace of methods rejected even earlier in the history of psychology--that is, mentalism, rationalism, and introspection. However, it is not behavioral experimentation in general that is to be rejected. It is the use to which experimental methods and principles have been put in the study of samples of behavior that are not representative of any known universe of behaviors, with experimental manipulations that are trivial. Moreover, these studies have not even been related to, or derived from, basic learning analyses. Actually, the basic principles of learning are quite well substantiated. And we have a burgeoning number of studies that are extending these principles to important samples of human behavior (see Staats, 1964; Ullman and Krasner, 1965).

One avenue of progress in psychological research should be in securing more and more representative samples, in experimental tasks, of the behaviors in which we are actually interested (Staats, 1963, 1964, 1968_a_, 1968_b_). Sometimes this must involve beginning with the description, in specific terms, of the universe of behaviors. That is certainly the case where the universe of behaviors is poorly specified--as in the examples previously mentioned of concepts, verbal learning, memory, communication, intelligence, reading, number skills, socialization, and so on. Many of these are no doubt not unitary universes but rather consist of various types of behavior. No doubt, also, many of these universes of actual human behavior are interrelated.

But even when there is some specification of the universe of behaviors, there is still the need for increasing the representative nature of the samples of the universe that are dealt with in the experiment. Although at one point of the game it may be appropriate to study some set of principles in the context of a simple reading task, for example, the task of understanding the development of the complete repertoire must necessarily involve getting more and more representative samples, up to the point where the principles can be employed to deal with the entire behavior itself. It is suggested that there really is no substitute for this. The final test of the relevance of some set of principles for a type of human behavior can never be completely made in the context of a sample of the behavior which has an unknown relationship to the universe of behavior. Ultimately, the principles established in experimental study must be shown to be relevant in dealing with the behavior itself in its recognizably natural form. Lack of recognition of this concept, it is suggested, has contributed to the sterility of a great deal of academic research on human learning.

The Need for Methodological Development in Studying Representative Samples of Complex Behavior

As has been implied, to some extent the lack of research on representative samples of human behavior and restriction to artificial samples have resulted from conceptual error. That is, in a young science trying to prove its basic nature, the taint of "application" was eschewed. This has led away from consideration of functional human behaviors. Moreover, a conception that there are internal mental processes that are the real determinants of human behavior has reduced our interest in the actual behavior studied--since from such a view it is the supposed internal process that is central. *Any* sample of behavior is seen as a suitable index of the internal process. (see Staats, 1968*b*, for a more complete discussion.)

However, in addition to this conceptual acceptance of experimental tasks without regard to their representative nature, there have been methodological reasons why complex, functional, behaviors have not been dealt with sufficiently. Survey of the experimental methods that are traditionally available reveals that none are sufficient for the task of studying complex, variegated behaviors that are acquired only over a long period of time and that involve many, many learning trials (see Staats, 1968a).

The traditional methods of experimental psychology, for example, are set up for the use of simple short-term, experimental tasks. Groups of subjects are used to statistically control for experimentally uncontrolled variations. However, the use of groups of subjects, has tended to preclude working with a subject for a long period of time in which various types of material are involved and various types of responses are made. Moreover, group results do not give information on individual processes. While the contribution of group research and the usual experimental-control, statistical comparisons is recognized, it must be suggested that the research method is not adequate or complete or maximally effective for the study of certain problems. Behaviors that are acquired only after many, many learning trials and that involve variegated stimuli, and responses, and where one wishes to observe the reactions of single subjects as well as groups, are not easily dealt with by short-term, group, experimental methods.

Single subject research methods were introduced by Skinner and his associates in the context of operant conditioning work (see Ferster and Skinner, 1957; Sidman, 1960) to study learning in the individual organism. Rather than giving one group one condition and another group another condition, this method has utilized the method of having the animal serve as his own control, and thus has worked with single animals. The organism is exposed to the experimental and control conditions, and detailed recording of the animal's behavior under the differing conditions is observed. This type of research may involve work with one animal that extends over a period that is long in comparison with traditional experimental research with groups--although it is brief in comparison with the research to be discussed. It is also true that the operant conditioning methods of research have been appropriate for work on only a single, simple response, such as pressing a bar. And such methods demand that one work with behaviors that can be returned to their original state, the state prior to the introduction of the experimental condition. The method is actually most appropriate for studying the effects on the rate of behavior of manipulating reinforcement conditions. As will be indicated, the method has been applied to child research in the study of reinforcement variables. There are, nevertheless, many human behaviors that are acquired only over a long period of time, and, once they have been produced, cannot be reversed. Moreover, once the importance of reinforcement has been shown in the realm of a particular type of human behavior, interest should shift to variables besides reinforcement that are also important in producing the behavior. This research progression will be shown in the research to be summarized.

There are, however, research methods that do deal with samples of complex human behavior, unlike the two experimental methods that have been described. Thus, for example, there is educational research that employs traditional group statistical methods but uses them to compare teaching methods. In a way, this research not only studies complex experimental manipulations and complex behaviors, but also may do this over long intervals such as a school year or more. To illustrate, one group of subjects may be given training in one type of reading program and a second group in another. The reading skill prior to and after the training may be tested (observed); or in some cases it may be observed only after training. Although the training extended to the subjects and the behavioral skills produced are complex, the behaviors observed (sampled) in the experiment again are of a very short-term variety--usually a test of an hour or so. Moreover, there is no detailed observation of the presentation of the stimulus materials. Thus, such studies manipulate representative samples of stimulus circumstances in an important human realm, and the behaviors produced may also be considered to be a representative sample of significant, functional skill. However, in both cases, the analysis and observation are completely inadequate. The different reading training methods receive only the grossest analysis. The reading skill is also unanalyzed and is observed only during the hour or two of testing. The specific relationships between stimulus manipulations and behaviors produced thus remain unknown in this research method. One could never use such data to trace the process of learning how to read, and this type of research method does not provide means by which to understand the role of basic learning principles in complex human learning or to understand the way in which complex behavioral repertoires are acquired. One does not even know in what manner one child learns well in the procedures and another poorly--and, in the latter case, where and how the learning behavior occurs.

There are also longitudinal methods of study that deal with behavior of some complexity. Such studies typically makes observations of children's behavioral development over long periods of time. While this type of research, like the others mentioned, can make essential contributions to knowledge, it is not experimental in the sense of manipulating some antecedent (causal) condition and observing an effect upon the consequent behavior. One can never establish from observations only of behavior what the determinants are of behavior development--although researchers who do longitudinal work commonly assume that there are heavy biological determinants involved, and that time itself is the independent variable. Because longitudinal research does not manipulate causal conditions, it does not provide information concerning what to do to produce a certain type of behavior in the child or how to alter behavior in any way. Piaget's work may be used as an example, since it is presently held in such high esteem. Essentially, this work consists in making observations of children at various age levels engaged in various complex tasks. The samples of behavior dealt with are representative of important behavioral skills--and the work has much to recommend it on this basis alone. However, there is no specific study of the conditions that produce the behaviors (whether of a learning or biological sort). One can obtain no specific information from this work concerning the determinants of the behavior development, or the principles by which this development takes place. The Piaget studies thus tell us nothing concerning what can be done to produce in a child a desirable behavior that has not developed or how to remove an undesirable behavior that has appeared. These limitations of this type of work are not generally understood. Moreover, the developmental norms produced by such longitudinal research methods may only be relative to the training circumstances of the children studied--not absolute in terms of biological development.

It is interesting to note, as an example of longitudinal research, that the same standards of research are not set for work such as Piaget's as for experimental studies in general. That is, many American psychology journals would not publish a study that did not involve a formal research design of some type that included control groups or control conditions and statistical or single-organism methods of insuring reliability. Piaget's work meets none of these standards. Yet his formulations are very influential in directing a great deal of research appearing in such journals. It is important to recognize this double standard for several reasons. For one thing, information that is contemporarily considered important may be produced by methods that do not utilize present experimental designs. The double standard thus may simply reflect the need for methodological development in research that deals with complex human behavior studied over long periods.

The foregoing is intended to illustrate a current problem in the study of complex human behavior. The fact is that our present formal modes of research are not constituted, as they now exist, to enable us to enter into important areas of study. Our choice of problems has been fixed by our methodology. Actually, the reverse should also pertain--our interest in research problems should have a greater effect upon our development of research methods. In brief, we need to begin dealing with representative samples of complex human behaviors. Many of these behaviors develop only over a long period of time, and our methods have to be designed to allow long-term study. Yet the research must be of an experimental nature in the sense that we study the antecedent conditions (learning) that produce the complex behaviors. Finally, the research methods must permit of detailed observations of the stimulus conditions that are being manipulated experimentally, as well as the behavioral products that are effected.

These requirements mean that innovation and development of research methods must be involved. This means, further, that the flexibility that goes with development will also be necessary. There has been a great tendency in psychological research for methods to crystallize into dogma. However, in extending the storehouse of substantive and methodological knowledge in psychology, there has to be greater influence by the subject matter studied, rather than dogmatically adhering to the research methods developed in the context of other problems. We have to begin with the behaviors themselves and apply the best experimental methods (in their general features) that are available and adapt them to the demands of the problem. There must be some middle ground between complete lack of experimental manipulation, the lack of concern with experimental principles of reliability, and so on, that are shown by naturalistic (including longitudinal) studies, and the restriction to unrepresentative samples of behavior that is shown by traditional experimental studies of the basic laboratory or of educational research.

The Research Progression

It was with these considerations, in incipient form, that the first author began the study of complex human behavior. A summary of this work is important here because the research to be reported herein must be viewed as part of a progressive series, and because a general method is characterized by the progression. To continue, however, along with his experimental-laboratory work, the first author had conducted a variety of experimental-naturalistic pieces of research--largely for his own knowledge and that of associates, since such studies did not have the formality necessary for publication. In 1958, however, he began a long-term project on the experimental study of representative samples of child behavior.

Several considerations were involved at the beginning. The samples of behavior to be studied had to be complex, functional in the child's adjustment, central to that adjustment, basic to the acquisition of other complex repertoires, and capable of study in their elementary, original, forms. The latter was essential for experimental purposes, both in terms of being able to deal with the behavior before the impact of other cultural agencies would confound the picture and also in terms of complex repertoires being more simple in their beginning stages. In addition, since language was considered to be central and unique in man's behavior, the samples of behavior chosen for study were aspects of language. A focal selection in the study of the child's cognitive development was the acquisition of reading.

The project began with exploratory work. In 1959, the first author had completed a token-reinforcer system for work with children. That is, the child was reinforced in a reading-learning task with plastic tokens of three values that could be exchanged for objects the child had selected to work for. The token-reinforcer system, in a study with several children with reading problems, had a clear effect upon work and attentional behavior--but the study did not have the formal properties required for publication. (The effects of the token-reinforcer system were widely disseminated informally, however, and led to applications by other investigators.) The next step was to more formally test the importance of reinforcement in reading acquisition. Moreover, the elementary principle involved was that in reading the visual verbal stimulus (the letter or word, or what have you) can be considered to be a discriminative stimulus that must come to control a particular verbal response or responses. According to the theory, the manner in which this takes place is that a response that is reinforced in the presence of a stimulus will come to be elicited by that stimulus (the principle of instrumental discrimination learning).

This possibility was first tested in the laboratory with four-year-old children. They were presented with a word stimulus, were prompted to say the name of the word while looking at the stimulus, and then were reinforced. A variation of the single-subject design was used, in which each child was his own control--a design that has been widely employed in other behavior modification studies with children (see Harris, Johnston, Kelley, and Wolf, 1964; Wolf, Giles, and Hall, 1968). That is, a child was introduced to the reading training without reinforcement, and the training was continued until the child requested cessation of the activity. The children would not engage in the task long without reinforcement. The condition was then changed, and the children were reinforced for their reading responses. The reinforcement (edibles and tokens) was effective in strengthening attending, working, and learning to read. In addition, several children were run in which they first received the reinforcement condition, then the no-reinforcement condition until they requested cessation of the activity, and then the reinforcement condition again. Again, with reinforcement, the four-year-old children's learning behavior was well maintained and they learned to read. When reinforcement was removed, their attention and learning deteriorated. When the reinforcement was reinstated, their learning behavior again became strong. It is notable that the results for each child were considered separately, and the experimental effect was evident in each of the six children employed in the study (Staats, Staats, Schutz, and Wolf, 1962).

This study lasted for eight 40-minute training sessions. However, reading acquisition is very complex learning that normally involves years of training. Although this was a representative sample of the behavior to some extent (the children acquired a word-reading repertoire of 15 to 17 words), it was necessary to progress in the direction of more representative samples of the behavior. One aspect of advancement involved the duration of the training since it takes a child a long time and many, many learning trials to learn to read. Thus, the next step was to run children in studies of alphabet learning that extended for six weeks. Again, with greater precision and control, the effects of reinforcement manipulations were studied with four-year-olds (Staats, Finley, Minke, and Wolf, 1964). It was found that the effects of reinforcement schedules pertained in the learning of complex letter-reading discriminations. Also, the previously employed token-reinforcer system was adapted for work with preschoolers in the laboratory situation in a study published in Child Development (Staats, Minke, Finley, Wolf, and Brooks, 1964). In these studies the children were studied for 30-40 training sessions of 20 minutes each. The possibilities of long-term experimental work were thus shown.

These studies were an important part of the development of the project. The elementary analysis of reading as instrumental discrimination was validated.

The effects of reinforcement were dramatically shown. However, the samples of behavior employed were far from representative of the actual universe--the tasks, the chunks of learning studied, were not sufficiently representative of those involved in actually training a young child to read. Moreover, it was seen by this time that to attempt to remain within the bounds of even the single-case laboratory studies, with the experimental condition versus the control condition comparison, was futile. The first author had begun intensive experimental-naturalistic studies with his own daughter in 1960 in the context of first language learning, sensory-motor learning, toilet training, and so on. It was evident from this experimental-naturalistic study that one could employ learning principles and procedures to produce complex, functional, behaviors in the child--cognitive behaviors as well as other types. The results were so clear that they could not be missed by anyone observing the process. These findings suggested that with the young child, in original learning tasks, the effects of learning manipulations could be seen dramatically.

Thus, in 1962 the first author began systematic studies of reading acquisition, number-concept learning, and writing acquisition with his daughter. Again, these were attempts not to deal with small (and possibly unrepresentative) samples of the complex behavioral repertoires but rather to deal with the universe--especially in the area of reading. The aim of the work was to produce functional repertoires, as well as to study the manner in which the repertoires are learned. As examples, the child was trained to read an alphabet, to read words individually and in sentences and short "stories," to read parts of words phonetically, and so on, to the point where she had full, functional reading skills. In the conduct of this training, furthermore, it was possible to test various learning hypotheses. For example, the child received discrimination training in making a sibilant-ending response when presented with a word ending in an s, and in leaving off the sibilant when the word had no s. After this discrimination training, with a limited number of words, the s as a stimulus at the end of a word came to control the sibilant response--she would, for example, read boy or boys correctly. Thus, the process of acquiring reading units, so-called word-sound correspondences, appeared to be learned according to the straightforward principle of instrumental discrimination. The expected generalization of this learning to new cases was tested by simply training her to read a new word without the s ending and then presenting the word with the s. It was found that the learned stimulus control of the s generalized to the new word. Other aspects of this study of the cognitive repertoire of reading that are of central importance to the present monograph will be referred to later.

The child was also trained to a letter-writing repertoire and to writing the complete alphabet without prompting, to write words based upon the "phonetic" reading training she had already received; and to discriminate the stimuli of number at an early age, to count objects when arranged in a series, to count randomly arranged groups of objects, and so on, by the time she was a little over three years of age.

At any rate, this experimental-naturalistic research was spread over a long period of time (from the age of two to the age of six). (Additional research was conducted with the author's second child, beginning when he was three.) It represented a very detailed study of the aspects of cognitive learning dealt with. Although the design of the research was not usual to the field of the experimental psychology of learning, the study was not only longitudinal in its extensity, it was experimental, involving the manipulation of learning variables and assessment of their effects upon behavior. Nevertheless, although the findings were clear to the first author in conducting the detailed observations, it was also clear that further developments were necessary to generalize the results and to work toward methods of greater formalization of the findings.

The next step in this development was to extend the study to other experimenter-trainers and to additional children. In 1963, several other children were presented with the same training procedures in individual studies. The children were studied in what was, especially at that time, a very long period for an experimental study. Thus, one child was involved in seven-and-a-half months of research which covered over 5,000 learning trials, some of them involving multiple sitmulus-response events. In the study of the cognitive learning of these childre, detailed observation of the acquisitions of functional reading repertoires was possible. Micro-experiments were conducted within the larger study, and additional empirical results were accumulated to begin to verify processes observed with the one previous subject. For example, the generalization of the stimulus control of the s stimulus on the basis of discrimination training was again found. Moreover, in the context of learning to read the letters of the alphabet, evidence was found supporting the previous observation of a learning acceleration due to early cognitive training. In addition, the learning produced by the presentation of stimuli such as boy-boys in a straight discrimination learning procedure confirmed the suggestion that children could also learn unit reading responses in this manner. Such reading units are also sometimes called grapheme-phoneme units, the learning of which is the focus of the linguistic method of teaching reading (Bloomfield and Barnhart, 1961).

To further study the learning of reading units, a specific micro-experiment was conducted in which the child was presented with combinations of vowels and consonants and given training on reading them to criterion. The intent was to experimentally observe the possibility that the child would come to respond correctly to the individual letters (for example, the consonants) through this word training on combined letters and combined sounds. In this micro-experiment, the child was trained to read da, ga, la, ka, na, and wa to a criterion of perfect performance over four consecutive, randomly ordered trials. Then the consonants were combined with another vowel and the child learned these combinations to criterion. In toto the six consonants were combined with the vowels a, e, i, o, and u. Then the whole training was repeated until the child could read all 30 syllables correctly to criterion. After this training, it appeared that the consonant stimuli controlled the appropriate consonant reading responses. The generality of this learning--that is, the acquisition of unit reading responses through the presentation of stimulus combinations--was then tested. The child was trained to read two new vowel letter stimuli. Then the new vowels were combined with the six consonants. In this test, the child read the novel combinations on first presentation with only two errors. These results which will be more elaborately studied herein, demonstrated a type of concept formation in the context of reading learning and indicated that learning reading units actually does occur on the basis of this type of discrimination training.

In addition, other hypotheses that had emerged from the experimental-longitudinal study with the one child were tested in the work with the additional children. For example, since each stimulus presented to the child and each response made were recorded, a test of the hypothesis that an acceleration in cognitive learning occurs as a function of cognitive training was possible. The number of learning trials required for the child to learn to read letters was tabulated over the course of learning to read the alphabet. A marked acceleration in learning to read the letters was shown for the three children.

It required three to five times as many learning trials to learn the first four letters as it did the third four letters.

At this point, however, only a few children had been dealt with. It is true that the observations were made over a long period of time, had involved a much more intensive investigation than ordinarily occurs, and had covered a much larger sample of behavior (learning trials) than ordinarily occurs. Behaviors had been studied that had previously not received the notice of experimental work. Nevertheless, the task was by no means complete, in several respects. For one thing, additional subjects were needed to provide an indication of the generality of the findings. The same was true of the use of various experimenters. The use of the experimental-longitudinal methods for the study of learning in the context of the child's complex cognitive development appeared to be quite productive. This is not to say that the methods required no further elaboration, however, in the same manner as the empirical results demanded development. Both avenues are concerns of the present monograph.

Although progression was shown in going from the one subject to the additional replications, and in moving from limited samples of experimental conditions and resulting behaviors to more representative samples, the process could not at this point be considered to be complete enough for formal statement. Since the methodological implications of the present project are so central, another aspect of the total project that demonstrates more fully the progression involved will be described before presenting the further empirical work in the study of the early learning of reading, number concepts, and writing.

Extensions of the Remedial Reading Research

In the introduction to the discussion of reading an informal study was cited involving several children who had problems in learning to read. In this

1959 study the first author developed the token-reinforcer system that has served throughout the present project, as well as in the research of others. This study provided corroboration of the ability of reinforcement to strengthen work and attentional behaviors that are fundamental to cognitive learning. These findings were then verified in laboratory studies, albeit with samples of behavior not closely representative of those involved in actual remedial reading training.

The first study of remedial reading in 1959 was conducted on too few subjects to get anything from an experimental-control comparison. Yet the length of time necessary to run subjects in a remedial training procedure that would have any evident effect was exorbitant for a group study. However, by 1963, the work with the single subjects in the laboratory, as well as the work just described above, indicated that systematic data could be obtained within the conduct of complex training procedures. Thus, in 1963, a study was conducted with one subject, who was given the experimental remedial reading training. Formal controls were not used--there was no other subject given the experimental treatment, nor was the single subject exposed to a formal control condition in addition to the experimental treatment--as traditional single-organism research methods demand.

Rather, the child's previous behavioral record was taken as the control period. Moreover, evidence of the systematic effects of the experimental treatment was sought in the detailed records of the subject's own behavior. The primary source of data for the study consisted of the subject's behavioral products. This was possible by recording every stimulus presented to the child, every response he made, and every reinforcer he gained. As one example, the rate at which the child made reading responses over the four-and-a-half-month period of training (40 hours) could be tabulated. The rate of responding was maintained with a slight increase, even though the material read became progressively more difficult. The short-term and long-term retention of the words learned was also tabulated. The ratio of reinforcers obtained per reading response made was tabulated, and it was shown that about halfway through the training the child, as planned, was getting about one-quarter as much reinforcement per response as he had at the beginning--while his rate of responding was maintained. Moreover, at the end of the semester the child received passing grades, for the first time in his history, although the training was conducted outside of the school. The child's aberrant behaviors in school also decreased markedly. In general, this child, who had been absolutely intransigent in the classroom, became a hardworking, attentive student in the experimental training. It appeared that the reinforcement system and training materials were effective with this one case and that it was possible to study the learning process involved through the methods employed, even though the materials were variegated. The methodological developments already tried in the other experimental-longitudinal work were productive in this context. The recording of every stimulus, every response, and every reinforcer provided important data concerning the learning process. (See Staats and Butterfield, 1965, for the complete study.)

The study provided considerable support for the thesis that reading behaviors are acquired according to learning principles, in children with learning problems as well as with young, normal children. The token-reinforcer system employed appeared to deal effectively with this particular case of learning difficulty. This is not to say that the evidence, even with respect to the specific points, was complete. It was supportive, but one study of this kind could not be taken as final--nor should any one study be considered in that manner. It is crucial to the methodology being expounded to have the study be one of a series--with prior supporting studies and later confirming and elaborating studies. In this manner one can obtain reliability and generality of evidence. This is true in any research, including studies that, like that on remedial reading, deal with only a single subject.

Thus, the Staats and Butterfield study was supported by the preceding laboratory research, which showed the importance of reinforcement principles in the context of reading acquisition. It was also supported by the experimental-longitudinal findings that investigated functional reading learning (although these had not reached the stage of development where they could be formally published). Still, additional data were necessary to establish the reliability and generality of the findings that remedial reading learning can be productively considered within a stimulus-response learning theory. Hence a replication study was conducted with 18 additional children who had problems of learning to read (Staats, Minke, Goodwin, and Landeen, 1967). The children, besides having learning disabilities, included cases who were mentally retarded or emotionally disturbed. It was therefore important to find that the behavioral results with the one case were very closely supported with the additional cases. A finding that the experimenter-trainers could be subprofessionals was also informative--the methods were so straightforward and the token-reinforcer system so effective that ordinary people could be employed to administer the training. (The experimenter-trainers were high-school seniors or adult volunteers.) An additional point of importance in this study was the use of a control group for comparisons on one of the aspects of behavioral data employed in the study. That is, a 100-word sample of the words included in the training materials (about 4,000 different words were involved in the universe) was given to the experimental and control subjects prior to and after the training given to the experimental subjects. The experimental group showed a large increase in the ability to read the 100-word sample and the difference was significantly greater than the increase for the control group, which was minimal.

Although this study provided verification for the learning analysis of remedial reading training, further evidence, including that of reliability and generality was needed. Consequently, another study has been conducted with 32 experimental subjects and 32 control subjects. The subjects were Negro children with learning disabilities who attended ghetto schools in Milwaukee. The experimenter-trainers were unemployed Negro adults, Negro adult volunteers, and Negro high-school students who were literate. At this stage, in addition to the behavioral data, appropriate achievement test data were collected from the experimental and control groups. The experimental group showed significant improvement over the control group in the 100-word test, grades, reading achievement scores, school attendance, and so on. Moreover, the behavioral data of the experimental subjects showed the same characteristics as those of the previous subjects--for example, acceleration in rate of response, decrease in the ratio of reinforcement, and so on (Staats, Minke, and Butts, in press).

This research has been summarized here in part because it, too, deals with a representative sample of one of the universes of behavior of concern herein--the acquisition of a reading repertoire. An even more central purpose, however, is to characterize the research strategy and the progression involved. That is, the research began with an interest in the problem, with realization that representative samples must ultimately be dealt with. The line of research was guided by the problem, not by set methodological requirements. The first study was of a naturalistic sort and was not formal enough for publication, although it yielded a good deal of information and launched the use of token-reinforcer systems. Laboratory research employing children as their own controls was then used and the basic principles were supported. With these findings as support, it was then possible to conduct a study with a single case without including formal control procedures. Such a study showed that data "internal" to the subject--the behavioral data of the subject--yielded systematic evidence of the effects of the learning manipulations. This type of data may be contrasted to the case where the data of the subject only become meaningful when compared to other data, usually obtained from other subjects. A later study extended this methodological use of the subject's own behavioral results as the basic data. It was shown that the single subject had produced results very like those obtained with 18 additional subjects. Only after a period of years and a series of studies was a formal control group introduced into the research methods and statistical comparisons made of measurements external to the behaviors involved in the training. The emphasis in this research progression was on the problem, with methods being adapted for relevance as the research advanced.

One of the strengths of such a developing research series is that each study does not stand alone--and a great deal of flexibility and innovation is possible. Not each study need include all of the controls required of the series. Different controls ranging from informal to formal are possible. Nor must each study deal with comparisons of the experimental subject (or subjects) to control subjects, or with comparisons of control to experimental periods. Systematic data may occur within the treatment to one subject as the treatment extends over time and involves complex learning. And development of methods to describe and assess such internal, behavioral data (a major focus of the present monograph) is very important.

Nevertheless, the requirements of good research need not be, nor can they be, sacrificed in the process of problem-determined innovation. The concerns for reliability and generality of observations remain just as important.

Progression towards formal methods of producing reliability and generality is to be sought and required. While each study in the type of series being described may not include formal controls, the series may be expected to advance to this level when it is appropriate to do so. A central part of these experimental-longitudinal methods has been insistence on studying the process of learning, not just its products.

The present monograph deals with original reading acquisition, number concept learning, and writing. It takes the principles, methods, and findings of the work with individual preschool children, and it tests, replicates, and extends them with additional children. A major concern of the monograph is in developing methods of treatment of the data and organizing the results to be relevant to further research development, theory construction, and hypothesis testing.

> When the experimental conditions have been stipulated in terms of basic principles, when the extra-experimental conditions and the subject's responses can be recorded, the results meet all the requirements of the data of natural science. The raw, untreated data fulfill these requirements, even without sophisticated ways of analysis. However, it may be suggested that when such raw data have been gathered, ways of organizing and evaluating them may be studied. The problems that arise in the recording and evaluation of this type of data are presently unique. In most basic research in psychology, for example, the stimulus is simple and the response is simple. In studying complex human behavior, however, many different stimuli will be used and many different responses will ensue.

> The ways of organizing and evaluating the data represent new challenges for the methodologist (Staats, 1968a, p. 570).

The previous presentation of the behavioral data of the long-term experiments involved the raw data shown in graphic form--as in the series of studies of remedial reading training. The present study takes behavioral data concerning the learning process for each young child and systematically characterizes the process graphically; it then statistically assesses the grouped data--in ways devised by the second author. This makes it possible to evaluate the reliability of some of the hypotheses established on the basis of the previous findings with single preschool subjects. Suggestions are also yielded for future development of the experimental-longitudinal methods of research. Using these methods it is possible to study the beginning learning of reading, number skills, and writing over a sufficient period to representatively sample the processes involved, which is the empirical concern of this monograph.

STUDY I: ALPHABET READING

Introduction

The first author participated in a conference on reading in 1963 which was attended by experimental psychologists, linguists, educational psychologists, reading researchers in education, reading specialists, individuals concerned with new reading orthographies--in fact with various types of individuals interested in reading. The question of what reading was arose several times and the answer was never given. None of the approaches could provide the answer. Actually, the skills that make up a reading repertoire are not generally known--in fact, it is commonly thought that reading skills somehow come to the child in large measure through physiological maturation.

In traditional educational controversy concerning the learning of reading, the issues customarily revolve around whether to train the child to whole words or to train him to reading units of some kind (grapheme-phoneme units). Actually, as indicated in an analysis of the learning of reading as an important aspect of language, a number of stimulus-response repertoires were outlined that compose a skilled reading repertoire (Staats, 1968a). Some of the most important elements of this repertoire lie in the child's previous language learning--which also involve multiple repertoires. These cannot be treated herein, of course. However, in the area of reading learning, it was suggested that one very basic skill was the discrimination of letters. That is, the stimuli involved in reading the letters are in the child's world of stimuli quite similar, even when generally considered (Staats, 1968a). If one trained a child to read the letter A mixed in with a group of pictures that the child also had to learn, it would be found that the child would also give the response to any other letter--B, G, or X, for example. In addition, there are closer similarities among the letters that give the discrimination task even greater difficulty. Moreover, the task is also difficult because the child must learn a response to each letter which is very similar. In simply learning the upper-case alphabet, the child has to learn 26 similar vocal responses to 26 similar visual stimuli.

In any event, "in the process of acquiring a reading repertoire the child must come to be able to look at the various letter stimuli presented in their various forms, and respond differently to each stimulus; that is, the child must learn to discriminate the letters" (Staats, 1968a, pp. 475-476). Alphabet training is one way to commence the various types of discrimination training that must be conducted with the individual letters. On the basis of this rationale, the first author employed the letter discrimination task, and alphabet learning, in his early experimental analysis of reading acquisition which has already been described. Chall (one of the participants in the above-mentioned conference) has since also emphasized the importance of alphabet learning in success in reading. After a survey of studies that correlate children's knowledge of the alphabet with later reading ability, she concludes "letter knowledge has a generally higher association with early reading success than mental ability as measured by various intelligence tests and other tests of language and verbal ability" (Chall, 1967, p. 141). Bond and Dykstra (1967) reached similar conclusions.

It would thus be expected that the nature of the alphabet learning process would be an important one to understand and to research. Moreover, it is one in which basic learning principles can be straightforwardly investigated. One aspect of the study of reading learning to be reported in detail herein involves the manner in which three- and four-year-old children acquire an alphabet reading repertoire on the basis of instrumental discrimination learning. The stimuli involved were first the single upper-case letters presented so that each letter would come to elicit a specific vocal response of naming the letter. In addition, the children learned to respond to the letter-stimuli presented in series. This was done to utilize the verbal response chain of saying the alphabet as a means of making the new letter response to be learned more available. That is, Staats has suggested that verbal response chains or sequences can be employed to make a reading learning task easier. Let us say "there was a strong TABLE-CHAIR word association for children. In constructing a reading program, if CHAIR was to be introduced to the child and he already could read TABLE AND, it might be wise to introduce CHAIR in the phrase TABLE AND CHAIR. The two preceding words would contribute to the stimuli tending to elicit the vocal response CHAIR and make it a more probable occurrence" (Staats, 1963, p. 463). Samuels has directly tested this hypothesis and shown that the S-R analysis holds in the context of this type of reading learning (Samuels, 1966). Moreover, Staats has shown in the previously described research that the child can easily learn a new letter response in the chain and this "word association" can be employed in training the child to a new letter reading response.

When the children were trained in the acquisition of the lower-case alphabet, another version of the same principle was employed. Since the upper-case letter already elicited the correct alphabet verbal response, it could be employed instead of having the experimenter say the letter. The upper-case letter was presented with the corresponding lower-case letter. The child would look at the new discriminative stimulus, then look at the old one that already elicited the correct response, then say the response as he looked back at the new letter.

These methods were derived from a straightforward stimulus-response analysis of the learning task and, like the other procedures and materials employed, had previously been used in either the previous experimental-naturalistic or experimental-longitudinal research.

Methods

Subjects

The subjects were 11 of 12 preschool children enrolled in the Child Learning Laboratory conducted in the Hawaii Curriculum Center campus laboratory school. The school ranges from preschool through the 12th grade. The children began their class in September and commenced their participation in the laboratory (the Child Learning Laboratory) at the beginning of October. Two children had to be replaced, one in November and one in January, because their parents moved to a different part of the country.

The children varied in racial admixture. There were five Hawaiian-Caucasian, two Japanese, one Japanese-Hawaiian, one Filipino, one Filipino-Japanese, and one Chinese. Almost all of the children were from families of lower than average income. Two were sponsored by the Community Action Program and several came from families economically just above this level. One child was an autistic or severely emotionally disturbed child who was in the group for other research purposes. The Stanford-Binet I.Q.'s and the ages of the children are listed, respectively, as follows: S_1 (84, 4 years and 1 month); S_2 (100, 3 years and 6 months); S_3 (98, 3 years and 11 months); S_4 (115, 4 years); S_5 (101, 4 years and 2 months); S_6 (92, 4 years and 6 months); S_7 (97, 4 years and 6 months); S_8 (121, 4 years and 1 month); S_9 (123, 4 years and 4 months); S_{10} (119, 4 years and 1 month); S_{11} (109, 4 years).

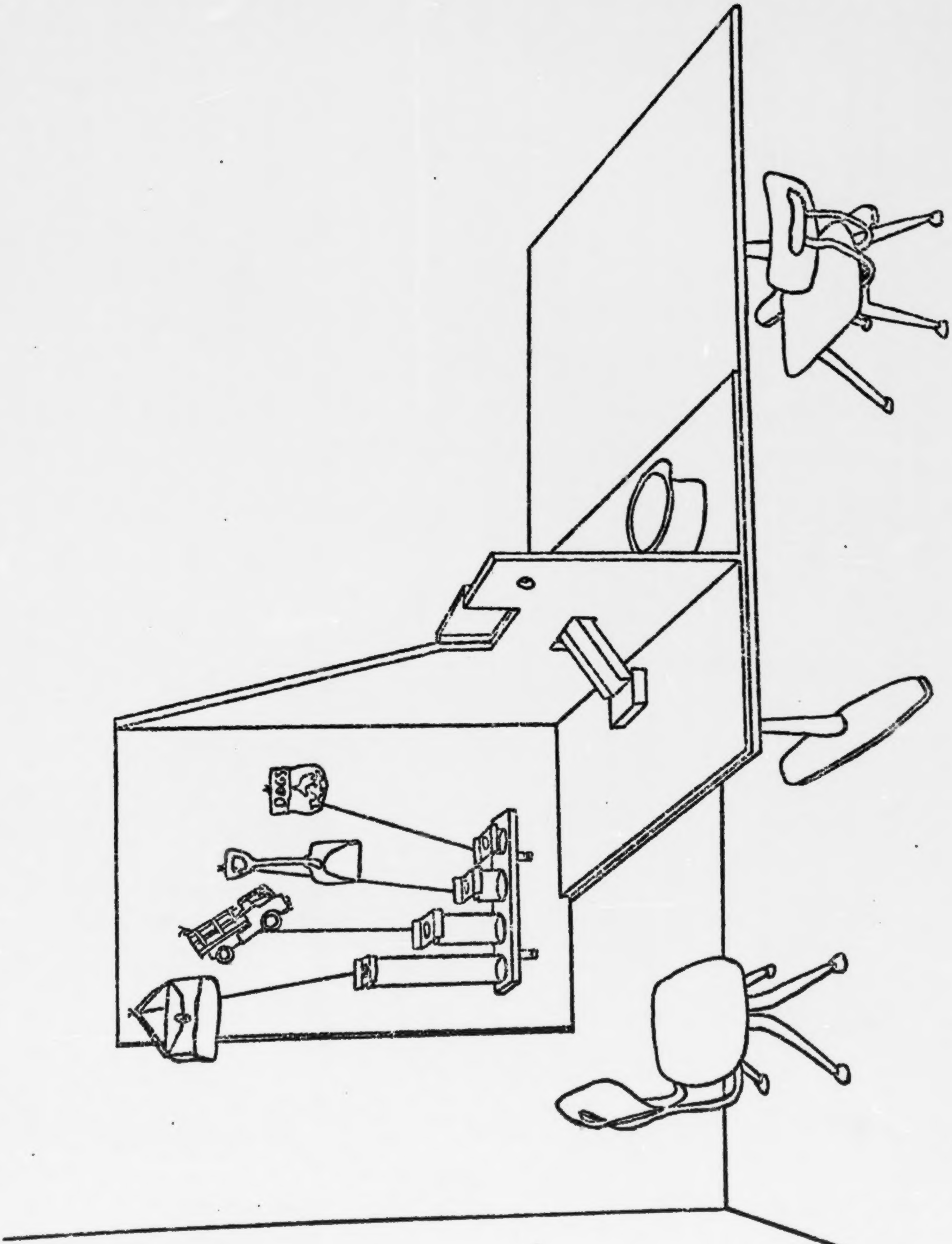
Apparatus

The apparatus employed in all of the experimentation to be reported in this monograph has been previously described (Staats, 1968c). It is essentially an apparatus for the presentation of various stimuli to the child, in conjunction with a token-reinforcer system. It was constructed (1) to deal with various types of learning of young children, (2) to maintain the attention and participation of the children for long periods of time and many, many training trials, (3) to be easy to deal with from the experimenter's standpoint, and (4) to be simple and economical to construct.

The apparatus is shown in Figure 1. It is made to be placed on a table for children (but could be constructed with legs of its own). The child sits facing a partition with a window in it in which 5" x 8" cards can be placed. Below the window is a chute ending in a wooden box. Marbles (the token-reinforcers) can be delivered to the child through the chute, as can trinkets or small edibles (peanuts or raisins, and so on). To the right of the window is a small hole into which the child may place a marble, which then drops into a plastic container on the experimenter-trainer's side of the partition. To the left of the child is a panel that extends from the partition. This panel has mounted on it a rack into which can be slid a board holding four plexiglass tubes of graduated heights. The two largest tubes were not used in the present studies. The next largest tube would hold 30 marbles, and the smallest tube would hold 10 marbles. Each tube, when in place, is just under a metal cover attached to the panel. Each metal cover has a hole in the center into which the child can deposit marbles that fall into the tube. Above each tube is a hook onto which toys the child selects can be hung. The experimenter-trainer's materials are on the side of the partition away from the child. The experimenter-trainer has access to these materials but can also observe the child.

Place Figure 1 about here

Both the child and the experimenter-trainer sit on chairs. The child faces the partition in which stimuli on 5" x 8" cards can be presented. In addition, the child can be presented with objects, as in counting training, on



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the space before him. Moreover, he can write, and so on, in that space. Yet the child is separated from the materials of the experimenter-trainer and cannot see them.

Token-Reinforcer System

The preschool teacher brought the child to the laboratory space at the beginning and introduced the child to the experimenter-trainer. The child was then given a very simple task (labeling a picture). Upon completing this response a marble was delivered through the chute in the apparatus. The child was told to put the marble in the hole just to the right of the window in the apparatus, and when he did this a reinforcer was delivered. The reinforcer was an item from the trinket-edible mixture employed. This mixture contained small plastic objects and edibles such as peanuts, M & M's, and so on. Several further pictures were presented and the responses reinforced. During the first session, which included three to 10 reinforced responses, the instructions became unnecessary and were gradually withdrawn.

On the second day, the teacher in the classroom gave the child a marble to take to the laboratory. When the child arrived at the apparatus, the experimenter-trainer simply told him to put the marble in the hole and delivered a reinforcer. The same procedure was continued for a week, after which the teacher merely told the child when it was his turn to go to the laboratory. One of the children who responded to all new situations or people with tears was brought to the basement by the teacher for three days, after which she came willingly herself.

From the second day the cognitive tasks were introduced among the picture naming. Throughout the training new tasks were reinforced continuously, but as the response became established the ratio was increased so that ultimately a schedule of reinforcement approximating variable ratio was used with all established responses. The experimenter-trainer was guided in the rate of reinforcement by the child's behavior. If the child showed any sign of inattentive behavior, responding slowly, looking around, and so on, the reinforcement ratio was increased (and the length of training session was shortened).

For the first three weeks the only alternative available to the child was a trinket-edible mixture, given on the ratio of one back-up reinforcer per one marble. After this, the children were introduced to the second stage of the reinforcement procedures. The child was told to choose from a display of small toys one for which to work. (The display was on a table near the entrance to the training situation.) This toy was hung above the smallest tube (which holds ten marbles). The child was instructed to place his marbles in the tube. This was continued until the child had filled the tube and received one back-up reinforcer. Then he had the option of working for the 10-marble toys or for the trinkets and edibles. After about 3 months of the study the 30-marble reinforcers were introduced. These toys were somewhat more costly and many tended to be larger than the 10-marble toys. The child was instructed to put his marbles in the 30-marble tube, in a procedure that was continued until the tube had been filled and the toy had been delivered. From then on to the end of the study, the children could use the reinforcer alternatives as desired: either the trinket and edible mixture on a one marble to one back-up reinforcer ratio, the small toys on a one to 10 ratio, or the larger toys on a one to 30 ratio.

The 10-marble toys were very small, some of them costing a penny or two. Examples are balloons, small plastic cars, party trinkets, crayons, small paper pads, brooches, plastic animals, and so on. The 30-marble toys cost usually 10 to 15 cents--with some running up to 25 cents. For additional discussion of the token-reinforcer system, see Staats, 1968a, 1968c; Staats, Minke, Finley, Wolf, and Brooks, 1964; Staats, Staats, Schutz, and Wolf, 1962.

The Laboratory-Classroom Complex

The complex in which the research was conducted consisted of a general classroom with adjacent office and bathrooms and an outside play area. Underneath the classroom was a basement area that included a room approximately 15 x 20 feet in length. Within this space, three of the apparatuses already described were dispersed. This made it possible to conduct the research-training activities with three children simultaneously. Although the children were in the same room, when occupied in the apparatus the children were oblivious of each other--and of observing adults, when they chanced to be present.

In the classroom the children engaged in the usual preschool activities: singing, painting, pasting, playing with blocks, playing with dolls, and so on. They also had scheduled play periods in the playground. The teacher of the preschool was instructed to refrain from giving the children cognitive learning trials in number, alphabet, or writing skills.

The children were scheduled for three periods in the classroom separated by two periods of free play in the playground. They were in class activities from about 8:30 to 9:20, in recess from 9:20 to 9:45, in class from 9:45 to 10:35, in recess from 10:35 to 11:00, and in class from 11:00 to 11:50. During the periods scheduled for classroom activities, each child would leave the classroom on a schedule and have his experimental session in the laboratory situation. Each child received training three times a day--in reading, number skills, and writing. (The writing training was conducted for teaching, not research purposes. That is, graduate students in psychology and educational psychology worked with a child for laboratory experience in learning-behavior modification research with children.)

Experimenter-Trainers

The training of children in the cognitive learning area of reading was conducted during the first semester by the second author, under the supervision of the first author. A graduate student in educational psychology, she had had no special training in working with preschool children--but does have children of her own who are beyond preschool age. During the second semester, four of the children were dealt with by another graduate student, Richard Stalling, under the supervision of the second author. This training was conducted as part of a child-learning laboratory course offered by the first author. The other seven children continued to be trained by the second author.

Stimulus Materials for Alphabet Reading Training

The materials consisted of several types: (1) A set of 100-line drawings of everyday objects and animals. These pictures were mounted on 5" x 8" cards for presentation in the window of the apparatus. (2) A set of 26 5" x 8" cards, each one containing a single upper-case letter of the alphabet. The letters were in black ParaTyph press-on lettering, futura medium style, 72 pt size. (3) A white cardboard display board measuring 10" x 12". The letters of the alphabet were serially arranged on the board in the same lettering described above. Thus, the letters were in rows of six, with two-inch spacing between the letters and between the rows. (4) A set of 26 5" x 8" cards, each with one upper-case letter and its corresponding lower-case letter printed upon it, in the same type of lettering. (5) A white cardboard display board of the type described above, for presentation of the lower-case letters in the series.

Alphabet Training Procedures (Behavior Modification)

In the first session, as described, the child was introduced to the use of the marble token-reinforcers. This was done in the context of a task involving the naming of pictures presented to the child in the window of the apparatus. In the second experimental-training session, several additional picture trials were first presented. The experimenter-trainer (E-T) then asked the child if he could say, "A." This served as a stimulus which elicited the imitational response of saying "A." The E-T then presented the A card in the frame in the apparatus, told the child that this was A, and said "Can you say 'A'?" Prompted trials of A were interspersed among picture trials. The trainer allowed the child time to respond unprompted, but was careful to prompt if the child hesitated or seemed about to make some other response. When it was no longer necessary to prompt A, trials on the display board were introduced. Only A and B were shown and the child was asked to point to A and say "A."

When the A response was strong, B was introduced in the same way. At first, trials on A and B were kept separate in sessions and the first response of each group was prompted. When both A and B responses were strong, sequences were presented: A cued followed by B cued interspersed with single trials of A. The cuing was then removed cautiously. When A - B sequences were strong, A - A - B, and later A - B - B, A - picture - B, and A - two pictures - B were introduced. At each stage the experimenter-trainer was careful to prevent the child from making errors. The previous work showed that the course of the learning can be disrupted if the child is allowed to make errors in this phase of the task. Trials were given on the display board with A and B shown and the instructions, "Point to A and say 'A'" and "Point to B and say 'B'," given.

C was introduced in the same way when the responses to A and B were strong. Sequence trials with C included A, B, and C. In this manner the upper-case letters were trained in order. When several letters had been trained, pictures were dropped out of the procedures. With each new letter, when the response had been learned, the letter was then presented in sequence with the several previous letters of the alphabet. For example, for P the sequence would be L M N O P. Finally, when P was strong in this sequence it was presented in random sequences with all the earlier letters in the alphabet. Hence the earlier letters were constantly being reviewed. Throughout the training the criterion of rapid, correct responses to all previously known letters, when presented randomly, was reached before a new letter was presented.

The lower-case letters were presented paired with the already known upper-case letters, the upper-case letters acting as cuing stimuli. These prompts were removed by covering the upper-case member of the pair. The A a card was presented and the child told that the small letter was also called "A." The paired *B*, *C*, and *D* cards were also shown in the same session and the smaller letters identified to the child as the small version of *B*, *C*, and *D*. The cards were then shown to the child in order, with the upper-case letter covered. If the child hesitated in responding, the cover was removed and the upper-case letter then prompted the correct response. These four cards were presented in order until responding was strong and unprompted. The cards were then presented in random order with the same cuing used where necessary until the four responses were strong. Practice was given with *a*, *b*, *c*, and *d* on the display board. After criterion performance was reached, two or three more letters were introduced and the same sequence of procedures followed.

Stimulus-Response Data Recording

The experimenter-trainers recorded every stimulus presented and every response of the child to the training stimuli--differentiating correct responses from cued responses and error responses. The time was taken for each session and the number of reinforcers given during each session was recorded. If the child made an error response, the nature of this error was recorded. The data sheets were ruled as grids. Each column represented a response and the row marking indicated which type of stimulus had been presented. A separate data sheet was used for each session. The data were summarized on a separate sheet at the end of each session.

Results and Conclusions

One of the children was able to read all but two of the upper-case letters of the alphabet, because of previous training by his mother. This boy, S_{10}, thus did not produce data for some of the experiments. He was trained to read the lower-case letters while the other children began with the upper-case letters. None of the other children could read any of the alphabet letters before training began. Of these 10 children, seven completed the upper-case letters and six of these learned the lower-case letters also. S_4 learned to L by the end of the second semester, at which stage her rate of acquisition of new letters was rapid. The remaining two children, S_1 and S_2, learned A through G. S_1 was learning rapidly by this time also. For S_2 the acquisition pace was increasing only gradually, but progressively.

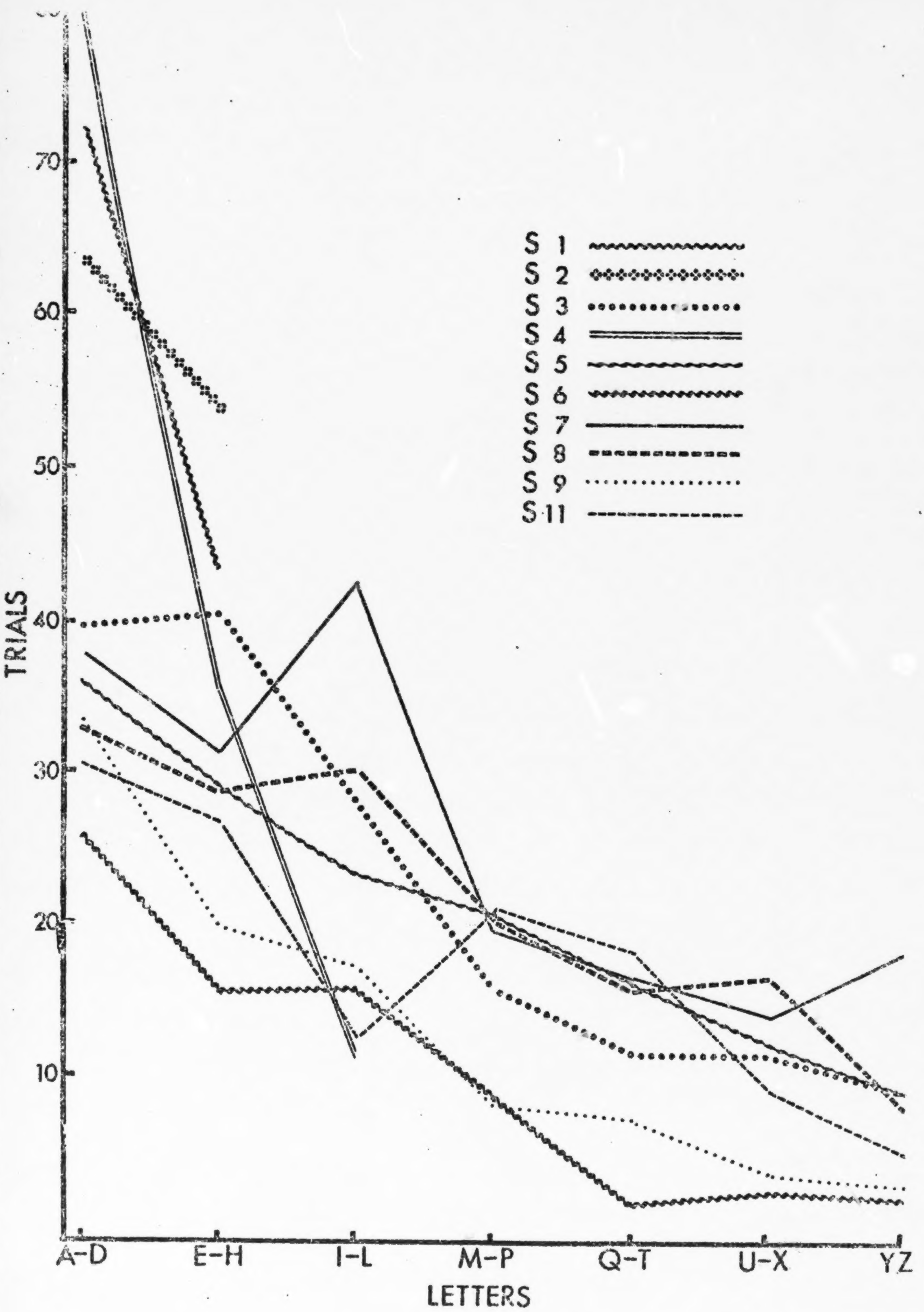
The criterion for the number of trials for learning a letter was taken as the number of trials of that letter up to the point of the presentation of the next letter. At this time the reading response to the letter had to be strongly learned; that is, the child had to be able to read the letter spontaneously whenever it was presented in any random combination with previously learned letters. Presentation of the next letter was also used as the criterion for the time taken to learn each letter and for the measure of the number of token-reinforcers employed.

In the following tables and figures, the letters are grouped in fours, A-D, E-H, and so on, and the mean for the four letters is presented. The last two letters, Y and Z, are averaged together. Figure 2 plots for each child the average number of trials required to learn to criterion each of the seven groups of upper-case letters. As indicated by the various curves, each of the 10 children took fewer learning trials to learn new letters to criterion as they progressed through the alphabet. For almost every one of the 10 children, the learning acceleration is evident after the beginning four letters and continues progressively (with some minor fluctuations) to the last set of letters.

Place Figure 2 about here

The group means for this learning progression are graphed in Figure 3, broken down into the seven children who completed the upper-case alphabet learning and the three who did not complete the task. The group means of the number of learning trials required to learn the letters show the same systematic effect, with the averaging erasing even the minor fluctuations. It takes a greater number of learning trials to learn the first letters, and the number of trials required appears to undergo a continuing although decelerating decrease throughout the task. It is interesting to note that a difference in learning rate between the seven children who did and the three who did not complete the learning task appears to occur mainly at the beginning of the learning process. That is, the three children took many more learning trials at the beginning of the learning task. The learning for the two children, however, was accelerating rapidly. For the one child who had gotten to the letter L, however, the learning was progressing as rapidly as for the other children. This finding, which is also evident with the other results to be discussed in this section, has general implications. That is, it can be interpreted as a suggestion that the difference in learning ability occurs because such basic skills as good attention and discrimination account for the original slowness in learning. Once these are acquired, the slow children learn as rapidly as the other children. Previous research (Staats, 1968a) substantiates this suggestion.

Place Figure 3 about here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TRIALS
A-D
E-H
I-L
M-P
Q-T
U-X
YZ
LETTERS
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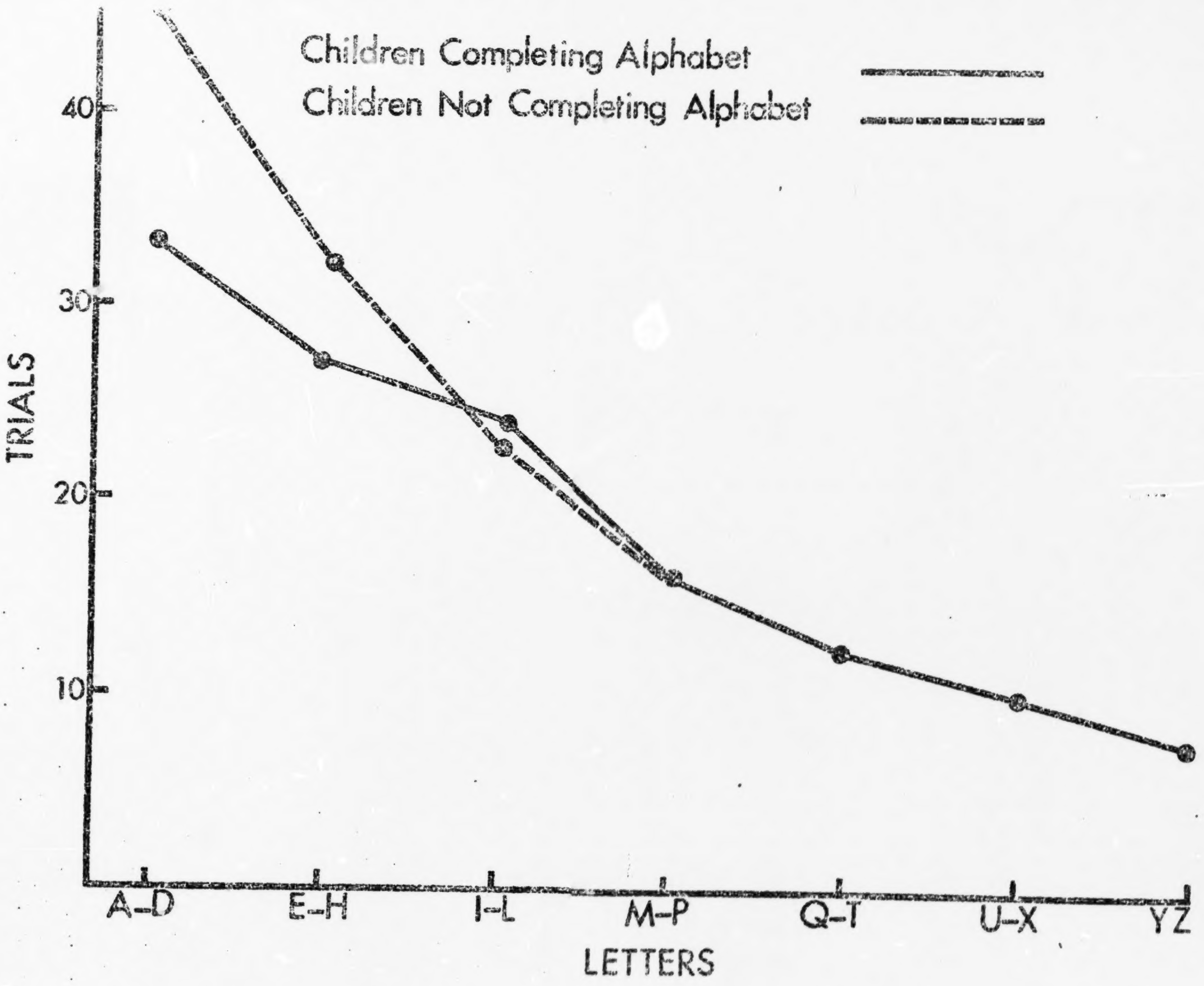
S 11


Children Completing Alphabet
Children Not Completing Alphabet
TRIALS
40
30
20
10
A–D
E–H
I–L
M–P
Q–T
U–X
YZ
LETTERS

An analysis of variance was performed on the data produced by the seven children who completed the 26-letter alphabet learning task. Table 1 describes this analysis and shows that the differences in the number of trials required to learn the groups of letters are statistically significant (at better than the .01 level). The means of the letter groups are in descending order and a trend analysis (as shown in Table 2) reveals a very significant linear trend (at better than the .01 level), and a smaller quadratic trend (at less than the .05 level) that describes the deceleration of the rate of decrease of learning trials required per letter.

Place Tables 1 and 2 about here

For each child the measure of time taken to learn each group of letters (Figure 4) shows, in each case, the same general function as the graph of the learning trials. The mean results for the seven children completing the alphabet learning task and the three children not completing the task are shown in Figure 5. The analysis of variance of the group data indicates that there is a significant difference(at better than the .01 level) between the groups of letters for the seven children (see Table 3). The trend analysis also revealed a significant linear trend (at less than the .01 level) as shown in Table 4. It should be noted that the measure of the time involved is a function of the speed of the experimenter-trainer as well as the speed of the child's responses. Four of the children whose graphs rise during presentation of the I-L letters were those who were transferred to another experimenter-trainer, and it is possible that the increase in the time taken at this point reflects the slower pace of the new trainer. It is also possible, however, that there is some increase in difficulty of learning the letter discriminations introduced at this point. It would be expected that there would be some difference in the comparative difficulty of discriminating the various letters, although the

Table 1

Analysis of Variance of Number of Trials Taken to Learn Successive Letters

Source	df	MS	F
Between Subjects	6	2,998.38	8.21**
Within Subjects	35		
Letters	5	9,560.67	26.19**
Residual	30	365.07	

**$p < .01$

Table 2

Trend Analysis of Number of Trials Taken to Learn Successive Letters

Trend	F
Linear	127.83**
Quadratic	5.565*

**$p < .01$
*$p < .05$

variable does not appear to be of over-riding importance in comparison to the training variable. This in itself is of considerable significance, since a good deal of interest has been shown in letter discriminability (see Dunn-Rankin, 1968).

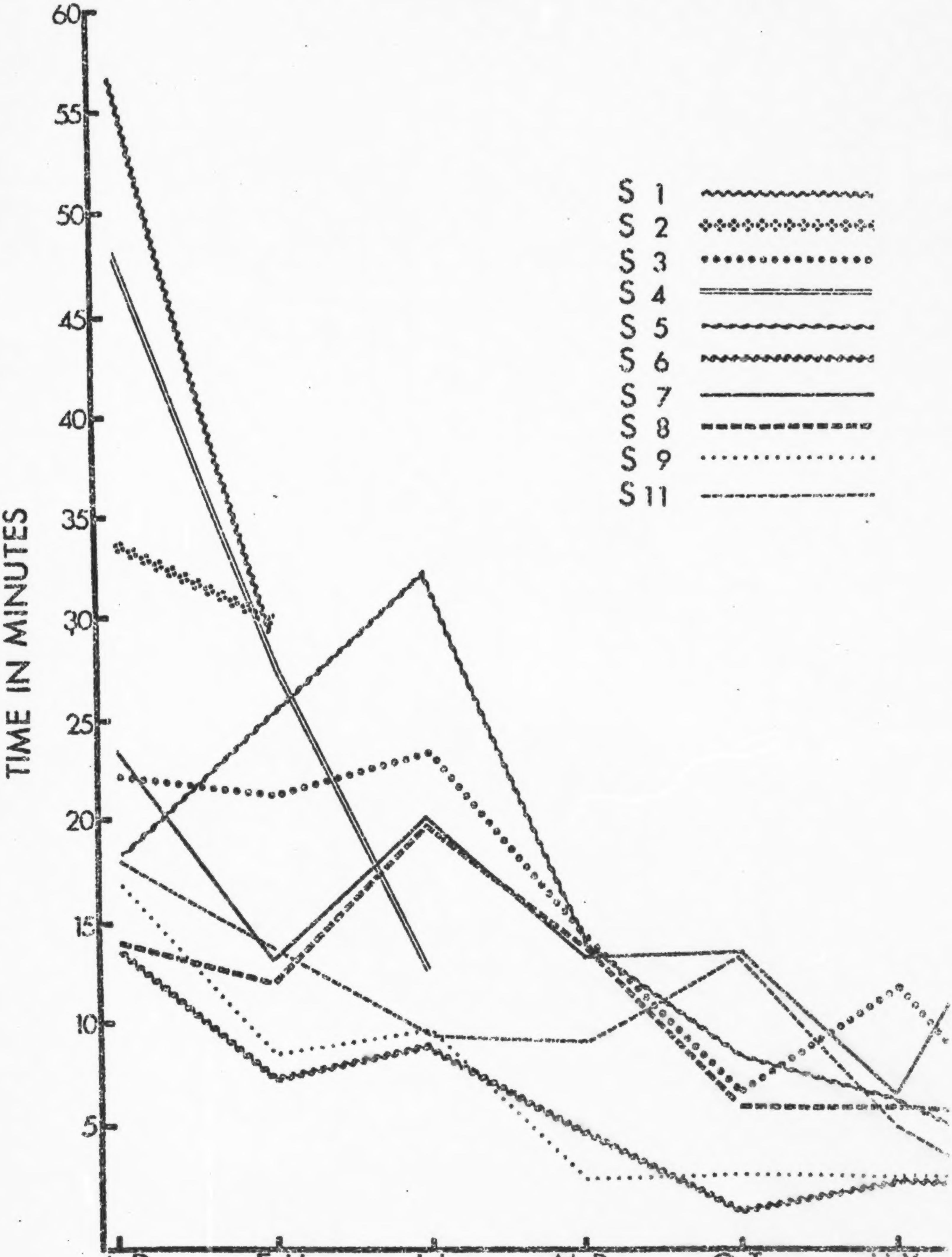
Place Figures 4 and 5 and Tables 3 and 4 about here

The same is true of the relationship between the number of token-reinforcers required and the successive learning of the groups of letters of the alphabet. In Figure 6, each record shows that a decreasing number of reinforcers was required in the training. The four children who were transferred to the new E-T showed a temporary reversal of the decreasing number of reinforcers required to learn each group of new letters. This would appear to be a function of the E-T's employment of a richer ratio of reinforcement than was necessary at this stage in training the children. The results for the seven children who completed the alphabet learning task and the three who did not are shown in Figure 7. The generally decreasing use of reinforcement per letter learned is demonstrated clearly in these curves.

Place Figures 6 and 7 about here

The analysis of variance of these data shows a significant decrease (at better than the .01 level) in the mean number of reinforcers required to learn the letters. This analysis is summarized in Table 5. Table 6 presents the trend analysis for these data which reveals that a progressively lower number of reinforcers is required over the learning task. The linear trend is significant at better than the .01 level. There is also a slight quadratic trend significant at better than the .01 level.

Place Tables 5 and 6 about here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5
TIME IN MINUTES
A-D
E-H
I-L
M-P
Q-T
U-X
LETTERS
S 1
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S 6
S 7
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S 9
S 11

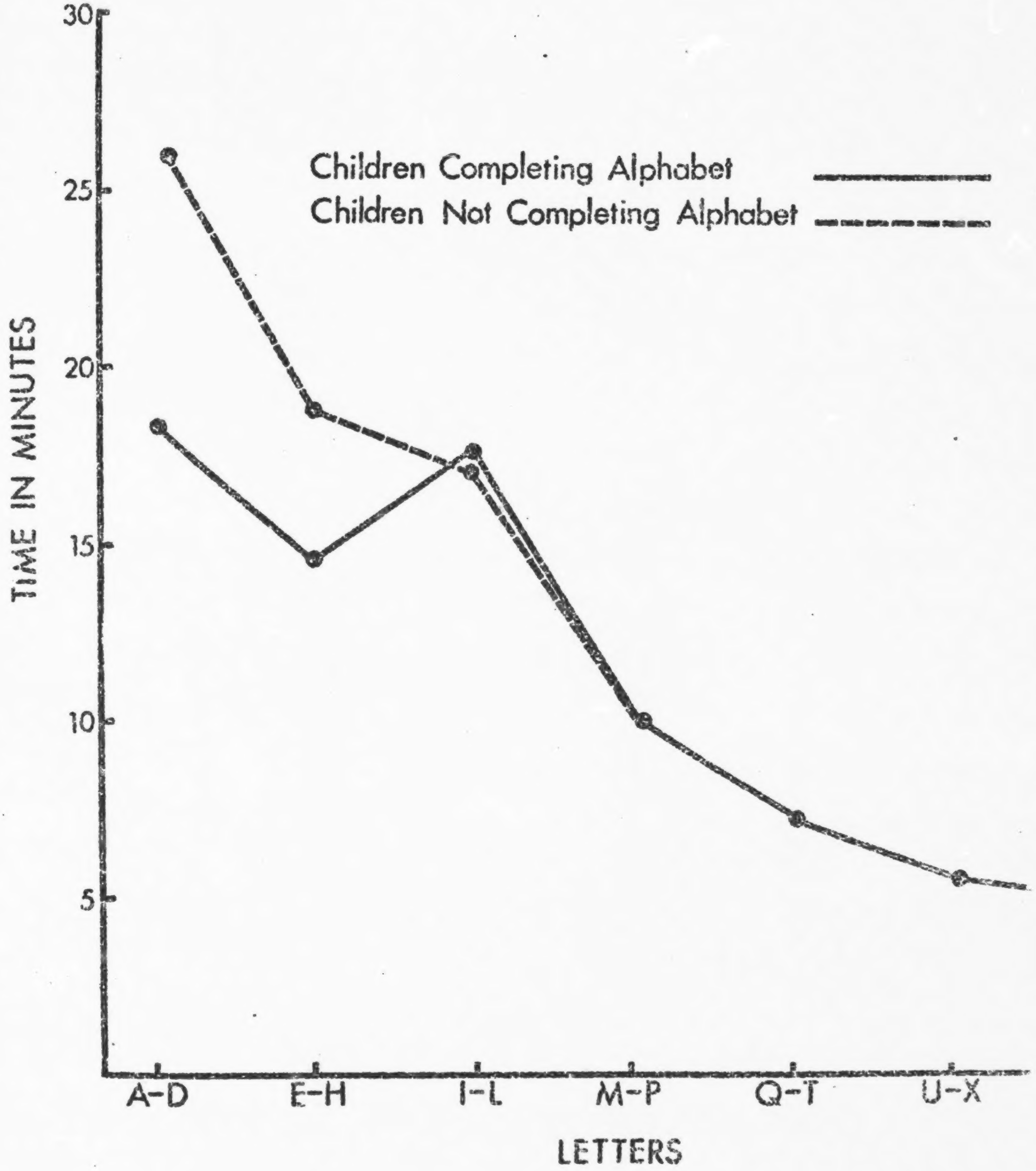

Children Completing Alphabet
Children Not Completing Alphabet
TIME IN MINUTES
30
25
20
15
10
5
A-D
E-H
I-L
M-P
Q-T
U-X
LETTERS

Table 3

Analysis of Variance of Time Taken to Learn Successive Letters

Source	df	MS	F
Between Subjects	6	11,575.66	46.89**
Within Subjects	35		
Letters	5	3,308.13	13.40**
Residual	30	246.85	

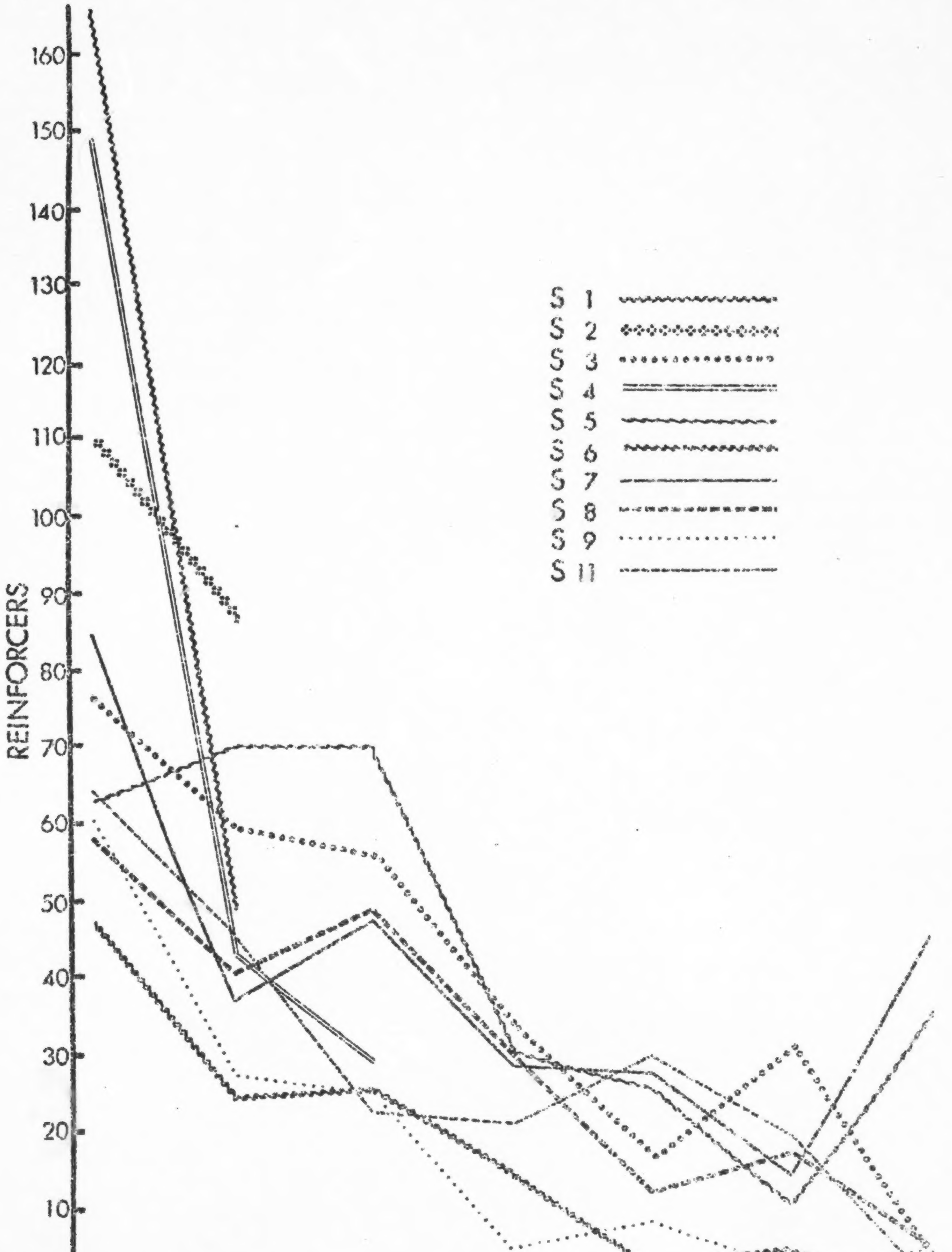
**p< .01

Table 4

Trend Analysis of Time Taken to Learn Successive Letters

Trend	F
Linear	56.96**
Quadratic	

**p<.01


160
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10
REINFORCERS
A-D
E-H
I-L
M-P
Q-T
U-X
YZ
LETTERS
S 1
S 2
S 3
S 4
S 5
S 6
S 7
S 8
S 9
S 11

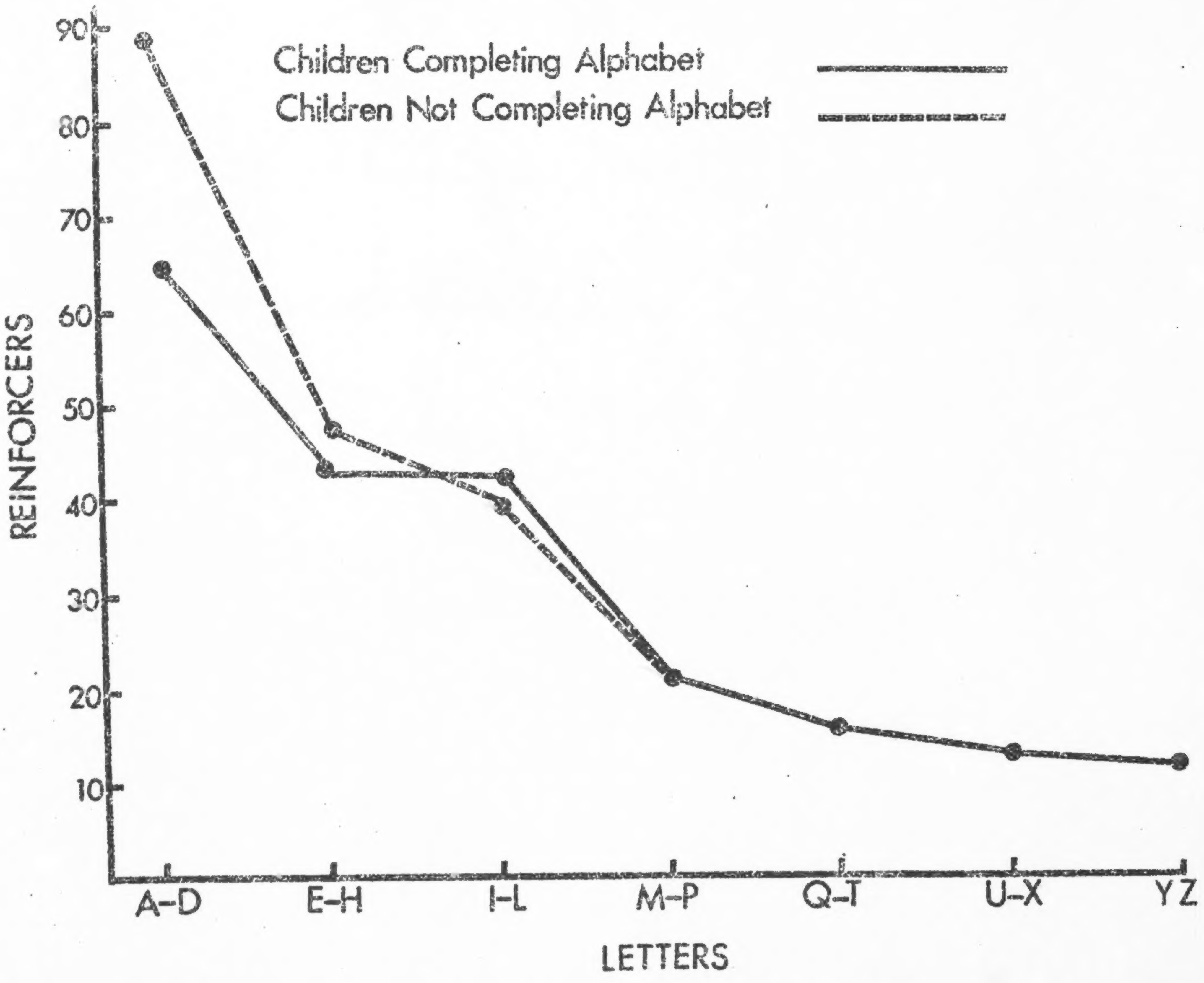

Children Completing Alphabet
Children Not Completing Alphabet
REINFORCERS
90
80
70
60
50
40
30
20
10
A–D
E–H
I–L
M–P
Q–T
U–X
YZ
LETTERS

Table 5

Analysis of Variance of Reinforcers Taken to Learn Successive Letters

Source	df	MS	F
Between Subjects	6	10,579.19	6.96**
Within Subjects	35		
Reinforcers	5	40,293.45	26.49**
Residual	30	1,520.55	

**$p < .01$

Table 6

Trend Analysis of Reinforcers Taken to Learn Successive Letters

Trend	F
Linear	125.06**
Quadratic	7.74**

**$p < .01$

In addition to the upper-case letters, the seven children completing the alphabet learning task were given training on the lower-case letters. A different procedure was employed here--based upon the fact that the children already could read the upper-case letters. The results showed very clearly that the learning of the lower-case letters was accomplished much more easily than the original training with the upper-case letters. Table 7 presents the total times involved for the children learning to read the upper-case letters and the total times involved in learning to read the lower-case letters. The mean times of the children who accomplished both learning tasks in the study were 4 hours and 25 minutes for the upper-case letters and 39 minutes for the lower-case letters later learned. This is a ratio of almost 7 to 1--the first learning taking almost 7 times as long as the second. It should be noted that some of the letters in the lower-case alphabet are more difficult to learn, since its letters are more similar to each other than those in the upper-case alphabet. On the other hand, since some of the letters are so similar to their upper-case counterparts, learning these particular letters is much easier.

The more precisely measured extent to which learning the second alphabet is easier than the first--another measure of the accelerating learning rate through learning--with these possibly confounding variables controlled, will require additional research. At any rate, the difference in times of learning for the two alphabets was subjected to a correlated t test. The results were significant at better than the .001 level.

Place Table 7 about here

Another analysis was made of the children's rate of reading responses over the period of training. The number of learning trials the child made per session was tabulated. Figure 8 plots this measure of the child's response rate. Since the children completed different numbers of sessions, the figure extends

Table 7

Total Times Taken to Learn Upper-Case and Lower-Case Letters

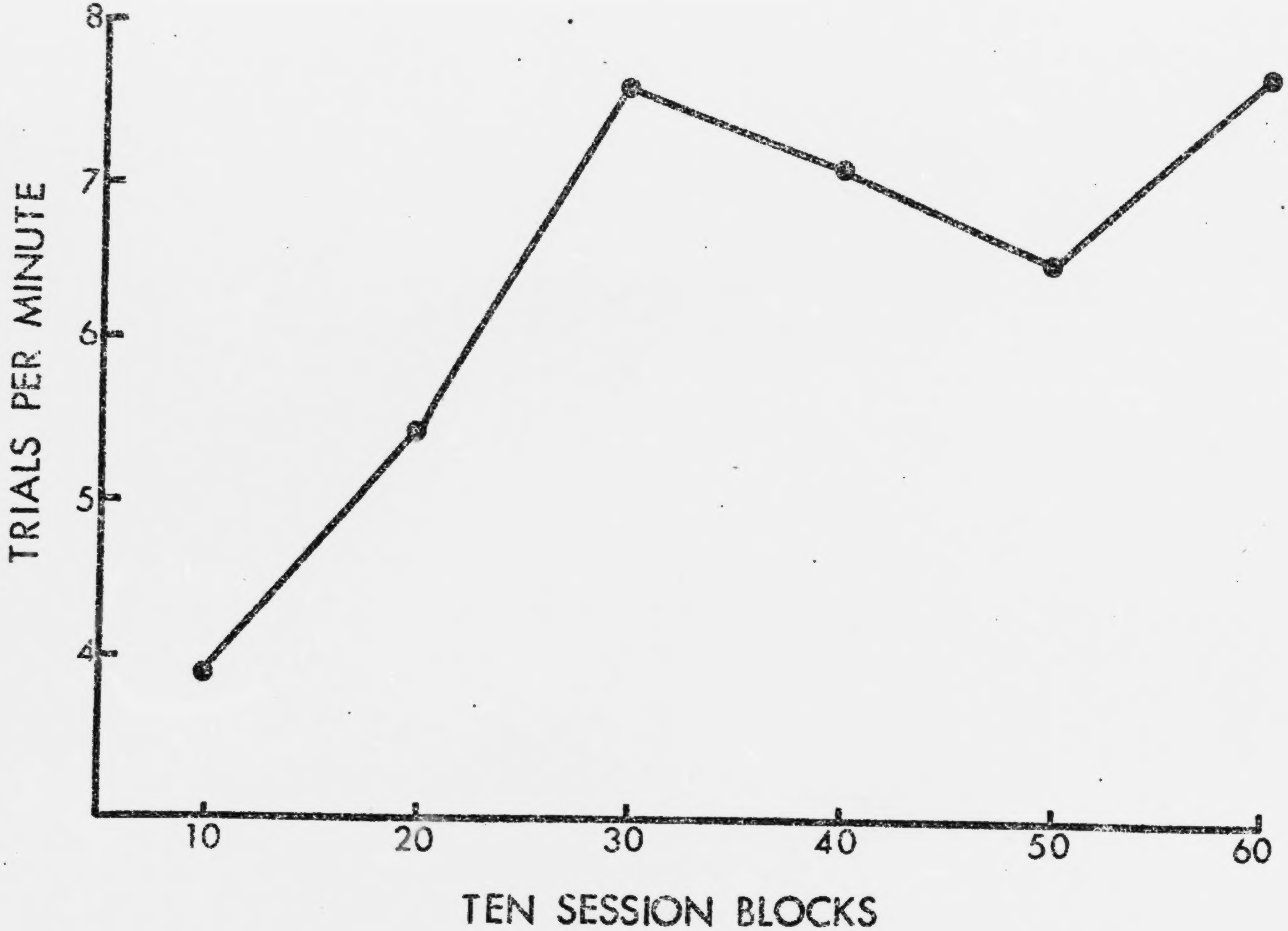
Child	Letters Completed	Time for UC	Time for LC
1	A-G	5 hrs 44.5 mins	
2	A-G	4 hrs 14.5 mins	
3	A-Z	6 hrs 47.5 mins	
4	A-L	5 hrs 52.5 mins	
5	A-Z, a-z	7 hrs 30.0 mins	43 mins
6	A-Z, a-z	2 hrs 36.5 mins	23.5 mins
7	A-Z, a-z	6 hrs 41.5 mins	43 mins
8	A-Z, a-z	5 hrs 17.5 mins	39 mins
9	A-Z, a-z	2 hrs 49.0 mins	42 mins
11	A-Z, a-z	4 hrs 37.0 mins	45 mins

only to the point where all the children are represented. (The increase in response rate for the children completing additional sessions levels off after the increase in rate shown on the figure.) Results of the analysis of variance of the differences in the mean response rates over the sessions are shown in Table 8. The differences in the mean rates are significant, (at better than the .01 level). Table 9 presents a summary of the results of the trend analysis of the data. As the table indicates, there was a linear increase in the rate of response from the first 20 sessions through the 60 training sessions (significant at better than the .01 level).

Place Figure 8 and Tables 8 and 9 about here

These results may be seen as the effects of improvement in the children's attention and work behaviors, and in their ability to respond quickly and precisely in the task. As the children's attentional and work behaviors improved (as the situation came to elicit the behaviors appropriate for learning), less time was spent on each discrimination trial. Fine recording of this progressive increase in attentional and discrimination behaviors with training has been shown by Staats and Heard in a study with retardates (see Staats, 1968a, pp. 240-262).

In the present work it is also possible to see clearly the gross increase in precision of the attentional and work behaviors of the children. At the very first, the children did not work and attend much differently than would be expected of three- and four-year-olds in a repetitive, arduous learning task. The children displayed behaviors irrelevant to the task--such as looking around, examining the reinforcers, and so on. However, the reinforcers rapidly gained control over the child's attentional behaviors and, after a short period, the children came to their apparatus with alacrity and purpose and worked



2

Table 8

Analysis of Variance of the Rate of Response as a Function of Training

Source	df	MS	F
Between Subjects	10	5.93	5.99
Within Subjects	55		
Rate	5	24.26	24.51**
Residual	50	.99	

$^{**}p < .01$

Table 9

Trend Analysis of Rate of Response as a Function of Training

Trend	F
Linear	62.91**

$^{**}p < .01$

consistently and hard in a manner that would ordinarily be characteristic only of much older children. This is perhaps one of the most startling effects of the apparatus, materials, and reinforcer system. The lawfulness of the improvement in the young child's working, attending, and learning under such a reinforcement system is surprising even to behaviorally oriented people--since the behavior produced is at such odds with the usual behavior of a preschooler in an arduous learning task.

Additional evidence to support the improvement in attentional and work behaviors of the child as a function of the training will be given later. It may also be noted here, however, that the criteria for determining the length of the learning sessions concerned the manner in which the child was responding to the arduous task involved. That is, the previous research (see Staats, 1968a) had shown that the length of the session was a variable to be suited to the child's learned ability to work (when reinforcement conditions are held constant). The child who has had less training in work-responding (which has a correlation with age, of course) will not work well for as long a period as a child with greater training. Judgment of the length of the training sessions (and to some extent, as will be seen, the richness of reinforcement) was a function of the goodness of the child's attentional and work behaviors. Note that in the first 20 training sessions after the letter training commenced the mean length of the sessions was 2.93 minutes. In the last 20 sessions of the alphabet training the mean length of session was 4.43 minutes. A correlated *t* ratio (of 12.23) indicates that this result was significant at better than the .01 level. Since this variation was determined by the "work habits" of the child, the result indicates the increase in good work habits as a function of training. In this context the mean length of training session, for the children who completed learning the upper- and lower-case letters, was 3.7. For the children who did not complete the task, the mean session length was 2.4. It is suggested that one of the variables underlying the rapidity of learning was the goodness of the children's work and attentional habits. The less good the attentional and work behaviors, the shorter the sessions, since the length of session was judged by the goodness of the behaviors. These results add to the evidence that the quality of the child's attentional and work behaviors is determined by his learning of such skills. Moreover, the quality of such skills is important to the rate and quality of the child's cognitive development (learning).

The mean number of learning trials involved in this extended learning for the 10 children was 2,035.6. A mean of 4 hours and 28.6 minutes in total time in training was spent in acquiring the reading skills. The training occurred in a mean of 85.7 training sessions, the mean length of the training sessions being 3.2 minutes. During the training, the children received a mean of 759.5 token-reinforcers. Thus, the ratio of reinforcers to responses was 1 to 2.68

Several aspects of these last results are of interest. First, it is possible to conduct long-term research with very young children that involves thousands of learning trials. However, not much total time is involved. Not a great deal of time away from the child's daily activities was necessary; yet over the period of the school year involved it was possible to conduct effective training. It may be concluded in the present study that the learning procedures, apparatus, and reinforcer system maintained the children's working and attentional behaviors in this extended and arduous learning task. This finding will be supplemented by the studies yet to be described.

Discussion

As already indicated, studies reveal that the best single predictor of first-grade reading achievement is the ability of the child to read the letters of the alphabet (Chall, 1967; Bond and Dykstra, 1967). These studies do not explain the reason for the correlation, do not analyze the reading learning task into its learning constituents, and do not demonstrate experimentally how such an apparently crucial repertoire is acquired by the child. As far as shown by the correlational studies, the child could come by his repertoire through physiological maturation as well as by learning. We have been in ignorance of the actual learning process involved. It is suggested that ignorance of the learning determinants of the acquisition of such complex repertoires predisposes one to conclude that the wide differences that are apparent in even very young children reflect individual differences in maturation.

Staats (1968a), however, has suggested that the alphabet-reading repertoire is a purely learned set of skills. Moreover, it was suggested that the elementary principle of instrumental discrimination learning--which has been isolated and studied in the animal laboratory--is involved. That is, the basic process hypothesized is that the letter is a stimulus. The child's response is the vocal naming of the letter. When the child's attentional behaviors and vocal responding are maintained by reinforcement--when the child says the name of the letter while scrutinizing it--the letter stimulus will come to elicit the naming response and the child will be said to read. It should be added, however, that the previous study of the first author has indicated that an analysis solely in terms of the simple principle of instrumental discrimination learning is incomplete. That is, in any process of discriminating a stimulus one must indicate what the stimulus is being discriminated from. In the context of the present learning task, let us say that the letter A is presented in alternation with a set of picture stimuli. After the child is prompted a few times and reinforced for saying "A" to the letter, he will quickly acquire the discrimination. It will appear that he is now able to read the letter--and in a sense he is. However, if at this point the child is presented with a _B_ (or other letter) in this situation, the child will ordinarily "read" the letter as "A." He will "discriminate" the _A_ from pictures, but not from a very similar stimulus, another letter. In this learning task, his reading discrimination is far from complete at this point. Moreover, it is at this point that the task becomes difficult. For to discriminate the first few letters of the alphabet requires in many cases a set of attentional and scrutiny skills the child has not yet acquired. Staats has found that one of the very most difficult parts of the reading learning task--complex as it is--is that of learning to read the first few letters of the alphabet. After the child acquires this small reading repertoire, and the attentional and discrimination skills involved, he is able to learn new vocal responses more rapidly under the control of other highly similar, highly abstract, visual stimuli in the process of acquiring a full reading repertoire. It is suggested that this is what underlies (explains) the fact that having an alphabet-reading repertoire is the best predictor of reading success when the child enters school.

The previous research of Staats (see 1968_a_) had suggested, with untreated data, that the child's acquisition of an alphabet-reading repertoire showed a learning acceleration. That is, a strong learning how to learn effect was shown in the context of this cognitive learning task. The present findings give firm support to this hypothesized process. Moreover, there is statistical support for the reliability of the effect. In addition, graphic presentation of the results of each child shows the learning acceleration effect to be general to the children and quite regular. In serial learning studies with adults, where all of the items to be learned are presented from the beginning, the first few and the last few items are learned with fewer learning trials than the middle items. These results are probably specific to the manner of presentation of the material. When the learning task is new to the subjects, and when they learn each unit before moving to the next unit, as in the present verbal learning task, the learning curve shows a decreasing number of learning trials per unit.

This finding receives further support from the difference in the amount of time required for the children to learn the upper-case alphabet in comparison with the time for the lower-case alphabet. Once the child has learned to read the one alphabet, the other one is learned with great ease. The regularity of this finding is again impressive. Unlike many studies in which it takes a group of subjects to show an effect, the relative ease of learning the second alphabet is shown by each and every one of the children involved. In cases such as these, it is actually superfluous to compute a statistic to show the reliability of the effect. Nevertheless, additional research to insure the generality of the effect with other materials should be conducted. The results at this point, stated in general terms, suggest that once a discriminative stimulus has come to control a response, the response may be brought under the control of a new stimulus by pairing it with the discriminative stimulus. Such higher-order instrumental learning appears to take place more easily than the original learning. Verification of this as a basic principle would have considerable import.[2]

The acceleration in learning that has been shown in the first reading acquisition task actually has very general significance. There has been in psychology and education a very strong conception that the child's development of behavioral skills depends upon his biological development. This conclusion has been based upon observation of what children ordinarily do do, and this is taken as evidence of what children are biologically prepared to do (see Staats, 1968, in press a, in press b). One derivation from this maturational conception is that it is useless and wasteful, and perhaps harmful, to attempt to train the child to cognitive skills before he is biologically ready. This is an injunction to abide by the status quo--which in general is inconsistent with science, and which in this particular case flies in the face of a learning conception of child development.

> . . . We have traditionally thought that observations of children's behavioral development reflected biological maturational processes. When we realize that what is actually reflected is the nature of the learning conditions to which the child is subjected, we also realize that observations of children's behavioral development are strictly relative and not absolute. The descriptions of child development that have been made and the (maturational) stages of development hypothesized are relative to the training customs of our society (Staats, 1968a, pp. 565-566).

The fact that an acceleration in cognitive learning is shown as a function of learning is in strong opposition to the injunctions against early training for children. The present and previous findings of the research project indicate that children are prepared to handle complex cognitive learning tasks at earlier ages than is traditionally thought to be the case. On top of this, the results show that the children not only learn specific skills through such early training, but also they come to learn additional skills more rapidly. Through training the children become better learners. The extent to which this learning acceleration occurs, the manner in which training in one area will generalize to another, and so on, must be explored in detail in research of the present type. More will be said of this later on. The possibility of a cognitive learning acceleration through learning, however, is of such significance that the later studies to be reported herein will emphasize the topic, within the realms of the other behaviors studied, when there is evidence of such an effect.

A word should also be said of two of the other results obtained in this study. As was shown, a decreasing number of reinforcers was necessary to produce learning as the alphabet-learning task progressed. Although not directly analogous, there is similarity in this finding to the previous finding that children in the remedial reading procedures already described required less reinforcement per reading response as training progressed (Staats and Butterfield, 1965; Staats, Minke, Goodwin, and Landeen, 1967; Staats, Minke, and Butts, in press). These results are important because they help set at rest the common fear that if the child is reinforced for learning (especially with material reinforcers) he will in the future be a less good learner, and will learn only if reinforced. Part of the answer to this reservation about the use of reinforcement procedures in child learning is given by the present results. When the child learns through reinforcement, his learning progresses more rapidly and he needs less reinforcement per unit of learning. It is the lessening reinforcement need that makes it possible for the child to come later under the control of other, weaker reinforcers. The sources of reinforcement change for the child as his reading ability grows (see Staats, 1968_a_). That is, there are no "intrinsic" sources of reinforcement for the child when first learning to read, and some form of "extrinsic" reinforcement is necessary to maintain the child's attention and working. As the learning becomes easier, less reinforcement is required. When the child has acquired reading skills in good measure, social and intrinsic reinforcement are available to maintain the behavior. The evidence that there is a lessening demand for reinforcement in the process of learning the skill is very significant in this context.

Additional evidence of lessening need for reinforcement will also appear in the next study.

Another finding in the present study was that the response rate of the children showed an increase over the first 40 training sessions. In such training the child not only increases his learning skill, but he also learns how to work. This means that, in the same length of time, the child after training obtains a greater number of learning trials than he did in the beginning. The importance of work habits or work skills, in academic as well as other endeavors, cannot be overestimated. Lack of the "ability" to respond rapidly in arduous learning tasks underlies many behavioral deficits acquired by children in school.

Again there is a close similarity of this acceleration in response rate to the results obtained with older children in the remedial reading task (Staats and Butterfield, 1965; Staats, et al., 1967; Staats, et. al, in press). The various subjects given the remedial reading training under the token-reinforcer system showed a positive acceleration in their rate of response, even when dealing with materials that became progressively more difficult. The fact that this process appears to occur across different samples of subjects (preschoolers, delinquents, retarded children, emotionally disturbed children, and children with learning disabilities), as well as across the different samples of the universe of reading behaviors, does suggest a good deal of generality.

Finally, the present line of research is unique in dealing with the child's acquisition of this very functional repertoire in a controlled, experimental manner. There is no research in experimental psychology or in educational research that treats this area of behavior, or produces the present types of results concerning principles of the cognitive learning, methods of research appropriate for studying such behaviors, or procedures and reinforcing system for producing such complex learning in children. The need for additional research of this kind will be treated further. It may only be mentioned, at this point, that these research interests were followed while the children were learning a functional cognitive skill of some importance.

STUDY II: LEARNING READING UNITS AND CLASSICAL CONCEPT FORMATION

The need for research which takes the basic principles and methods of experimental psychology as the means with which to study more and more representative samples of human behavior has been discussed in the introduction to the present monograph. The preceding study applied the basic principle of instrumental discrimination learning to the alphabet learning of preschool children. The present study continues the theoretical and experimental analysis of reading utilizing basic principles and methods.

To begin, concepts and concept formation have traditionally been studied in the context of animals learning discriminations, with children classifying pictures or objects by simple stimulus dimensions such as size or color, and so on. Usually in these studies the ability to classify by stimulus dimension has previously been learned by the subjects. In a classic study Hull (1920) employed Chinese characters as the stimuli, and had the adult subjects learn names to the characters. These characters consisted of certain classes. That is, all the characters to be called by one name were dissimilar in some respects, but similar in having a common component. It was found that that a common stimulus element, a component of a more complex stimulus configuration, could come to elicit a verbal response--in a process that may now be seen as instrumental discrimination learning. From an S-R analysis it could be said that the common stimulus element is "abstracted out " in the process of training in the sense that it comes to be the stimulus that elicits the response. Staats (1968a) has suggested that such stimulus-response mechanisms are important to various complex human behaviors. How such an S-R mechanism does indeed operate in the context of significant, functional, human behaviors should be shown experimentally. The task of learning to read is an area within which to study the S-R mechanism of a common part of various stimuli coming to elicit a response. As will be seen, this type of learning mechanism is an important aspect of what has been called "breaking the code" in the process of gaining reading skills.

To begin, however, it has been suggested that the child should learn to read for meaning. This has been translated into procedures in which the greatest emphasis is placed upon reading whole words as the basic unit of training, since parts of the word have no independent meaning. When one interprets the reading learning task in these terms, the suggestion is to proceed by having the child learn to read many, many, whole words. The rationale should also provide for the child having a fantastically large number of training trials in which to learn the thousands of words he must come to read.

Others have suggested in different theoretical contexts that the child, rather, must learn to break the code, to acquire grapheme-phoneme correspondences or, in plain language, to learn to read parts of words. In the language of stimulus-response learning theory (Staats, 1968a), when the child can respond to parts of the word stimulus seen in a left-to-right sequence and can also respond with vocal reading units in appropriate series, the child may sound out new words he has never seen before. This analysis is much more realistic than the first interpretation of reading, for it means that the child has much less to learn. Rather than having the task in his formal training of learning 10,000 to 20,000 reading responses to that many separate words, he is prepared to read words himself, without receiving externally given prompts of formal training trials, once the child has learned his "sounding out" repertoire of skills.

Experimentally several questions arise in the context of this analysis. (Actually, the child ultimately has to learn thousands of whole-word reading responses to whole-word stimuli--see Staats, 1968a--but he also has to learn reading units.) The one most usually dealt with concerns which method of teaching reading is superior. The attempt then is to compare the complex reading methods across classes, teachers, materials, and so on. As already indicated, this is done when the only observations of the children's learning are a pre-test and post-test of reading skill. Such studies have been unable to answer the question of which method is better--code breaking or learning to read meaningful whole words. More seriously, however, such research has not, and cannot, reveal anything about the nature of the learning task.

Research is necessary to analyze the learning task in specific stimulus-response terms. Then experimentation must be conducted in which individual children are presented with training materials derived from the analysis. Detailed observations must be made of the children in the learning task to ascertain how they do indeed learn. The first author, for example, attempted first to teach his little girl to read on the basis of the whole-word method, after first training her to read the alphabets (Staats, 1968a). He found that the whole-word reading training proceeded well at the beginning. However, a point was reached, after she had acquired a word-reading repertoire of some hundred or so words, at which it became more difficult to introduce new words while maintaining her ability to read the old ones. The whole-word reading method by itself did not appear to be efficacious, when the progress of the child was observed in detail. Staats found the training to be more expeditious when the child was trained to reading units less than a whole word--to letter and syllable reading units.

Even when this decision is made, however, there are various ways that the task can be conceived of when a stimulus-response analysis is made.

Perhaps, for example, the child should be trained to respond to single letters with the smallest units of speech that can be defined--in linguistic terms, grapheme-phoneme correspondences. Staats (see 1968a) also conducted research with his own child and other children to see whether it was effective to have the child first learn to say phonetically p, a, and t. When this repertoire had been learned, the child would be presented with the letters in a series (as in a word) and trained to run the sound together to form a whole-word response from the printed stimuli. This proved to be a very difficult way to begin to train the child to reading units so that he could later sound out new words he had never read before. For one thing, letters are not pronounced the same way when presented by themselves as they are when presented as part of a word. The strategy of training defeats itself when the child is trained to pronounce the letter one way when it is by itself and then another way when with other letters in a word.

However, it has also been suggested that children can be presented with whole-word training in a way that "allows them to break the code." Bloomfield (Bloomfield and Bernhart, 1961) has suggested that children should be trained to read employing words with regular spelling such as fat, cat, pat, mat, and so on. As with the other methods for training the child to read, however, there is no analysis of the reading task in learning terms. What would be accomplished by this training in terms of the child's reading skills is not indicated. Moreover, there has been no experimental evidence that such learning can indeed take place, or if it does, what the process is like.

A stimulus-response analysis of this learning task can be made, in terms of the type of concept formation that has already been described, that suggests that reading units can be learned from systematically arranged, whole-word presentation. That is, if fat, cat, pat, and mat were presented to the child and he was prompted to say the appropriate word in each case while looking at the word, it would be expected that the part stimuli would come to control the appropriate consonant response in pronouncing the word. Part of a complex stimulus would come to control a response. This would not be a case where a common part of a stimulus came to control the same response, as in Hull's concept formation. It would be a case where the uncommon part of the stimulus (the initial consonant) would come to control its own individual response along with the common response components (the vowel-consonant ending). Staats first treated the possibility that such learning would take place in the context of reading learning with his own child, and then the findings were generalized with other children. In the later case, the child was presented with consonant vowel combinations like da, ga, la, ka, na, and wa, which were learned to criterion. Later, each of the consonants was combined in the same way with the other vowels--e, i, o, and u--and each set was learned to criterion. The entire learning was then repeated until the child read the 30 combinations perfectly. In this the child was trained to read all the d syllables, all the g syllables, the l syllables and so on. Each response was tabulated so the course of the learning could be charted. As a consequence of this training, it appeared he learned a repertoire of reading units--where, for example, the different consonant letters came to control the appropriate consonant reading response. The existence of this general learning was tested by training the child to read two new vowels by themselves. Then the consonants he had been trained on were combined with the new vowel. The child read the new syllables almost perfectly without further training. It was also shown that the syllables he had learned to read could be combined together in larger units (corresponding to a two-syllable word) and he could read the combinations.

This study, which was conducted in 1963, provided evidence that a type of concept formation may occur in the child's reading training. Moreover, the results showed that in this training the child can acquire reading units that are functional in learning to read new syllables and new word combinations. The present study was designed to test these findings with additional children in the context of learning an actual word reading repertoire. The first four children who completed the task of learning the upper-and lower-case alphabets were then introduced to the concept formation type of learning task in which they learned a basic repertoire of word-reading responses. Whether the children would learn reading units smaller than the whole words with which they were presented in the training was an object of study, as were the characteristics of the learning process.

Method

The general conditions were employed in the second study as in the first. The subjects were the first four children to finish the alphabet-reading task. The same apparatus, facilities, data recording methods, and so on, were employed. The experimenter-trainer was the second author.

Stimulus Materials for the Reading Units (Concept Formation) Task

Thirty-six 5" x 8" cards were used. On each card was printed a single word. The classes of words are shown in Table 10. The words constituted a combination of one of six initial consonants (c, m, p, r, s, or t), with the single vowel a, and one of six terminal consonants (d, m, p, n, g, or t).

Place Table 10 about here

In addition, the letters of the upper-and lower-case alphabets were employed, typed singly on 5" x 8" cards.

Reading Unit (Concept Formation) Training Procedures

Prior to commencing the reading unit training, the child had to be

Table 10

The Words Used in the Reading Concept Formation Task

Set 1	Set 2	Set 3	Set 4	Set 5	Set 6
cad	cam	cap	can	cag	cat
mad	mam	map	man	mag	mat
pad	pam	pap	pan	pag	pat
rad	ram	rap	ran	rag	rat
sad	sam	sap	san	sag	sat
tad	tam	tap	tan	tag	tat

trained how to read the letters when presented in primary size type, since training to this point had involved the larger letters. Several sessions were spent training the children to read the individually presented letters of the upper-and lower-case alphabets.

Following this, the training in the reading concept formation task began. The first set of cards (Set 1) was presented to the child one at a time. The experimenter-trainer said the word and the child repeated it while looking at the stimulus card. The set was presented again in the same serial order; the experimenter then allowed time for the child to respond unprompted if he could, otherwise he prompted as before. The experimenter continued to present the six cards in serial order, reinforcing responding with a marble once or twice in each set, but not consistently following the same syllable. The presentation of the first set in serial order continued through as many sessions as necessary until the child could respond correctly to the cards unprompted through three continuous presentations of the set. The cards were then presented in broken serial order, that is, retaining the same order but beginning from a different member of the set on each presentation. After reaching the second criterion of three correct unprompted trials with this type of presentation, the cards were presented in random order. The child reached the third criterion when he could respond correctly without prompts to three randomly ordered presentations of the set.

At this stage the first set of cards was set aside and Set 2 was presented in the same way until the same three criteria had been met. The other sets were also presented in the same manner. After the six sets had been learned in this way, the whole procedure was repeated to the same learning criterion. Then it was repeated again for the third time. Next all 36 cards were treated as one set, and the same procedure was followed; presentation was continued until the 36 were read correctly three times. Only one child reached this final stage of the procedures before the end of the semester. However, during the final sessions, regardless of what stage the children had reached, further tests of the generalization of the concepts were made.

One of the primary purposes of the study was to test the extent to which the children had actually learned reading units from the presentation of "whole" words in the concept formation learning procedure. That is, would the reading units generalize to new combinations? This was tested by training the children to new reading elements and then combining the new elements with those presumably learned in the concept formation task. The possibility of the children reading the novel combination of separately learned reading elements was then assessed by presenting the combinations to them one at a time. Table 11 summarizes the training given the children to provide them with new reading elements that could be combined with the hypothesized already learned elements. The combinations of the new elements with those already learned are also given in the table. The children's data indicating their ability to read the new compound stimuli are also shown in the table, as will be discussed in the Results section.

Place Table 11 about here

To test for the possibility that the children had learned to read the beginning consonants as units--separate from their combinations with the specific syllables involved in the concept formation training--the children were first given training in a new syllable ending, ab. That is, they were trained to read cab, which they had not previously learned. The learning criterion was three correct reading trials in succession, as was the case for the other new elements learned for the generalization assessment. The procedure used to train

Table 11

Summary of the Generalization Training and Test Materials and Generalization Results

I

Child	New Syllable	New Element Learned	Combination of New Element with Already Learned Elements for Generalization Test			
	cab	ab	rab	sab	tab	pab
6			+	+	+	+
10			+	+	+	+
9			+	+	-	+
11			+	+	-	+

II

Child	New Syllable	New Element Learned	Combination of New Element with Already Learned Elements for Generalization Test			
	ax	ax	max	sax	tax	pax
6			+	+	+	+
10			+	+	+	+
9			-	-	-	+
11			+	+	+	-

III

Child	New Syllable	New Element Learned	Combination of New Element with Already Learned Elements for Generalization Test		
	bad	ba	bag	ban	bat
6			+	+	+
10			-	-	-
11			-	-	-

the child to *cab* mixed the word presentations with picture presentations. Then the syllable *ab* was combined with beginning consonants that had been part of the material they had already learned. The combinations on which the children had never received training were *rab*, *sab*, *tab*, and *pab*. Success in reading the novel combinations would demand that the beginning consonants had been learned as separate reading units and that the syllable ending *ab* had been learned as a separate reading unit in the just previous training.

In the second test of generalization, the new element learned by the children was the ending *ax*, presented without an initial consonant. After this had been learned to criterion (which was again three successive correct reading responses) the syllable was combined with the beginning consonants *m*, *s*, *t*, and *p*. The novel combinations produced were *max*, *sax*, *tax*, and *pax*. Whether the children could read these novel combinations on first presentation was again a test of the possibility that the concept formation training had made the beginning consonants separate reading elements that could be combined with others. This generalization additionally tested the possibility that the syllable *ax* could be learned by itself, without a beginning consonant, and then combined with a beginning consonant and read for the first time in that manner.

The third test for generalization examined whether the last letters of the trigrams had been learned as a separate unit in the concept formation training. The children were trained to a new word, *bad*, which employed an initial consonant on which they had not yet been trained. This word was then presented among other members of Set 1 ending in *ad*, that is, with *cad*, *mad*, *pad*, *had*, *sad*, and *tad*. Following the results obtained from the first generalization test, it was expected that the children would learn to rea the *b* letter as a beginning consonant. After this training in reading the word bad had been conducted to criterion, they were then presented with the b in novel combinations, with the elements ag, an, and at in the words bag, ban, and bat.

Results and Conclusions

Subjects 6, 9, 10, and 11 took part in this study, since they had finished the alphabet learning task with enough time left in the school year to begin the present study with a reasonable chance for completion. Of these four children, only S_6 completed the entire reading concept formation task. S_{10} finished the task through the second presentation of the six sets. S_9 went through the first presentation of the six sets and the second presentation of the first four sets. S_{11} finished the first presentation of the six sets and the second presentation of the first two sets (see Figure 9).

The data concerning the extent to which this type of concept formation training in reading will yield reading units that will generalize to novel combinations will be dealt with first. The children were given the several materials to test for generalization during the last week of school. It should be noted that S_9 was absent the last day and missed the last test of generalization. Table 11 summarizes the new syllable (or word) the child learned for the generalization test, as well as the new reading element that was acquired in this process. The table also lists the novel combinations that constituted the generalization test and the results when each child was presented with the new combination of reading elements. If he read the new combinations correctly, he was scored with a +. The minus signs record failure to read the new combinations.

The first test of generalization concerned whether the beginning consonants that had been presented in the concept formation task had become abstracted and would control the consonant reading responses in new combinations.

When the new syllable ab was joined with the consonants in the words rab, sab, tab, and pab, two of the children read the new combinations perfectly on first presentation. Children 9 and 11 missed on tab, and thus demonstrated the generalization on three of the four opportunities. This result is analogous to the previous findings (Staats, pp. 309-315) which showed that initial consonants can be learned as units in a reading concept formation task.

The next test for generalization involved having the children learn a separate syllable ax. This syllable was then combined with a consonant to see if the two elements, separately learned, would be read correctly in combination. This generalization test was similar in principle to the first, except the new element was learned alone and not as part of a larger word. Children 6 and 10 again performed perfectly. Subject 9 read only one of the new combinations out of four. Subject 11 read three of the four presented. Again, there was strong evidence for this type of generalization--although the two children who had the weakest learning in the concept formation task showed the least learning of the consonant reading units.

The third test of generalization involved the vowel and the final consonant--rather than the initial consonant as in the first two tests. The children were trained to read a new initial consonant (b) in a new concept formation task in combination with one of the already learned final syllables (ad). Then the b was combined with several of the other already learned final syllables to make the words bag, ban, and bat. Child 6, who had completed the original concept formation reading task to criterion, showed that the learning of the vowel and the final consonant as an element may take place. This child showed perfect generalization. The other two children who had not completed the original learning to criterion did not evidence learning of the final two-letter syllable as a reading element.

These results fit quite perfectly with the design of the training materials and the extent to which the children were exposed to the materials. Until the latter stages of the total concept formation task, the training was actually only on the initial consonant. In the first set of words, for example, the initial consonant was the only letter that varied and could come to control the specific reading response required in any particular case. The same was true of the training the child received on the other five sets of words; he was given the terminal consonant response for each set and the response remained constant across that set. The stimulus and response to be discriminated involved only the initial consonant. (The fact that the learning of the final consonant did not take place in this training was seen when the children could not read the final consonants each time the set of words was changed.) Only later, when the various sets of words were mixed and presented to the child in training did a discrimination have to be made in terms of the terminal as well as the initial consonant.

To continue, the two children who did not receive the concept formation training on the final consonant did not evidence in the generalization test that the final consonant had become a separate reading element. The one child who did receive the concept formation training on the final consonant showed that it had become abstracted as a stimulus and would function as a separate reading element in controlling the appropriate response in combination with other preceding elements.

A number of questions for further research arise in the context of the present findings. For example, it might be that the initial consonants can be learned more rapidly than a terminal consonant, and that medial vowels are learned less rapidly. If such differences exist, knowledge of them would be important in the design of reading-training materials for children. There may also be ways of accelerating this type of learning--for example, by distinguishing the letter to be discriminated at the beginning by color or a slight separation from the other letters. A major implication of the findings is to suggest methods for continued study.

In addition to this evidence that the child actually can learn reading elements (letter-sound correspondences, grapheme-phoneme correspondences, or what have you) in this type of concept formation task, data was collected that more precisely describes the form of the learning that took place in the training. Each learning trial on the materials presented to the children was recorded, making it possible to plot the course of the learning involved. The results are shown in Figure 9. The mean number of learning trials taken over the course of the first presentation of the six sets of words produces a learning curve for each child. The curves in the first six sets of words, as indicated, record the extent to which the child has learned the initial consonant as the stimulus controlling his reading responses. The mean number of trials to learn to read correctly the words cad, mad, pad, rad, sad, and tad--the first set of words--was 109. The number of learning trials necessary with the second set of words--cam, mam, pam, nam, sam, and tam--took a mean of only 24.5. The children continued to require fewer and fewer learning trials on each successive set of words to be learned, as the figure shows.

Place Tables 12 and 13 about here

The results suggest that a major portion of the learning with respect to the initial consonant had taken place in the first set of words even though improvement continues at a decreased pace through the second presentation of

Table 12

Analysis of Variance of Number of Trials to Learn Successive Sets of Words Differing in Initial Consonants

Source	df	MS	F
Between Subjects	3	1,309.61	2.98
Within Subjects	20		
Sets	5	4,682.70	10.66**
Residual	15	439.45	

**$p < .01$

Table 13

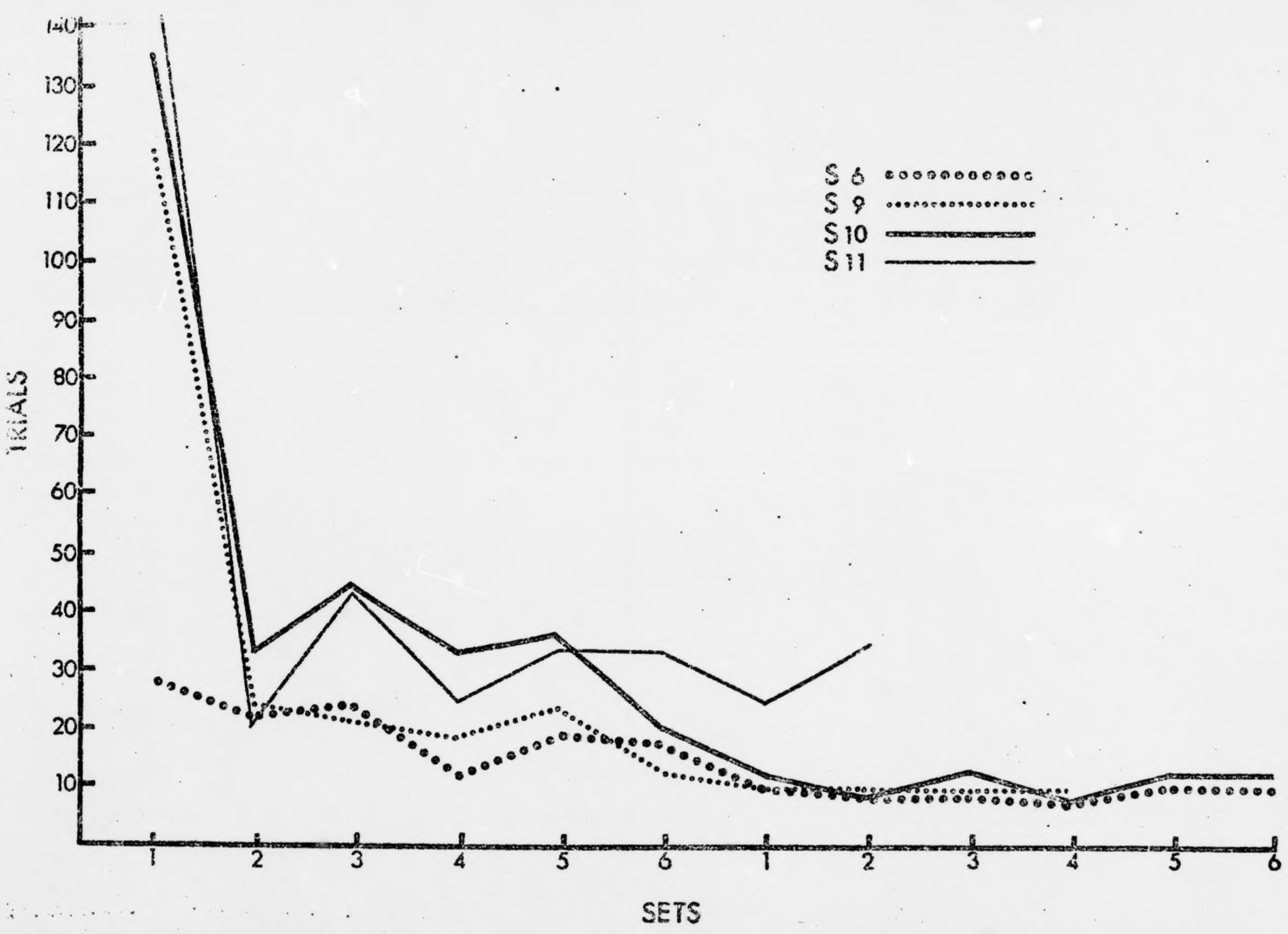
Trend Analysis of Number of Trials to Learn Successive Sets of Words Differing in Initial Consonants

Trend	F
Linear	25.00**
Quadratic	19.75**

**$p < .01$

Place Figure 9 about here

The analysis of the results of this learning (through the first presentation of the six sets of words) indicated that there was a significant difference (at better than the .01 level) in the learning trials required to learn the successive sets of words. The analysis of variance is given in Table 12. The trend analysis of the data in Table 13 shows a significant linear trend and a significant quadratic component (both at better than the .01 level).


S 6
S 9
S 10
S 11
TRIALS
140
130
120
110
100
90
80
70
60
50
40
30
20
10
1
2
3
4
5
6
1
2
3
4
5
6
SETS

the six sets of words. One can suppose that a considerable amount of the abstraction of the initial consonants out of the whole word presentation had occurred within the first set of six words. A test of generalization at this point might have revealed this learning. The present findings, at any rate, indicate that the concept learning process functions for the acquisition of reading units, and give evidence concerning the form of the learning. But it is still an initial effort at opening the area for study and additional research should be conducted to investigate the learning process in greater detail.

There is in all likelihood also a learning-how-to-learn effect in the learning curves. This effect cannot be pulled out of the present data, however, and will have to be studied in future experiments. For example, if the children had first received training on several words differing in the initial consonants, would they then require fewer learning trials to learn to read several new words with different initial consonants? The results in the other areas of this monograph, plus the present results, would suggest that such a learning acceleration would take place in this type of concept formation also. Moreover, it would be interesting to investigate whether training in the "abstraction" of an initial consonant would accelerate learning of a final consonant "concept." A number of other hypotheses should be studied. For example, there was no variation of the middle letter (the vowel) in the three-letter words employed. A concept formation task could be composed which included variation in all three letters to study the relative efficacy of the concept formation. Such studies could be conducted to provide understanding of the learning processes involved, as well as to produce information concerning the most advantageous types of learning tasks to present to children in their reading training.

The number of learning trials the children made in this study are interesting to note. The mean number of single word learning trials for the four children was 1,734. The mean total time involved was 2 hours and 57 minutes, which occurred in a mean of 35.8 training sessions. The mean length of training session was 4.9 minutes. During the training, the children received a mean of 357.5 reinforcers. The mean ratio of reinforcers to responses for the children was 1 to 4.85. Thus, it can be seen that the reinforcement ratio was made "leaner" from the 2.68 ratio used in the alphabet training. This is additional evidence, in agreement with the other findings, that the use of extrinsic reinforcement in training children can be gradually reduced. The learning task was an arduous one which demanded close attention through a very repetitive learning task. As in the preceding study, however, the children's active participation and close attention were maintained throughout--a telling indication of the efficacy of the reinforcer system and the learning procedures.

Discussion

The results show that a child can learn S-R elements from training on stimulus units presented in combinations. The data of the decreasing learning trials required for the word sets show the process in which a part stimulus, the initial consonants, came to control the appropriate whole-word reading response. The fact that the first and second tests of generalization occurred showed that the part of the stimulus, the initial consonant, had come to control the part response, the vocalization of the initial consonant--independent of the other part of the word vocalization that was involved. To elaborate, in learning to read rad, sad, tad, and the rest, and ran, tan, pan, and so on, the child was learning several things. First, the individual whole words as stimuli came to elicit whole-word responses. Since the initial consonant in the first set of words constituted the only differentiating cue, the initial consonant was responsible for controlling in each case the appropriate initial consonant vocalization. The fact that this type of learning had taken place was shown by the savings involved in learning the second set of words (cam, mam, pam, ram, and so on). Considerably fewer learning trials were necessary in this learning task.

This, however, does not constitute evidence that the initial consonant stimuli could control initial consonant responses, separately, without the rest of the word stimuli (and the word responses) that had been involved in the original training being present (that is the ad, am, ap stimuli and sounds, and so on). Thus, the initial consonants r, s, t, and p were joined with the new syllables ab and ax. It was found that the part stimuli, the initial consonants, elicited the appropriate consonant responses even when paired with new letters to form novel word stimuli. That is, the initial consonants had indeed come to elicit the initial consonant responses when combined with new elements.

The training also included in the late stages, variation in the final consonant of the words among the six sets of words. The children had to respond to the final consonant letter with the appropriate consonant response to read the various sets of words properly when the 36 words were presented as one set. This training was given to only one child. A clear discrimination of the final consonant was not demanded by the learning task until the words with the different consonant endings were presented more closely together and mixed. It is important to note that only the child who had participated in the latter type of training demonstrated the functioning of the final consonant stimulus as an independent unit in controlling the final consonant response. The other two children did not. The results rather clearly suggest that the concept formation training on the final consonant was necessary for it to become abstracted as a reading element.

The study demonstrates that the manner and form of the learning by which children acquire complex repertoires such as reading may be experimentally produced and studied. Statements about children's learning of reading have been largely conjectural, based upon very sketchy and incomplete observations of children actually engaged in learning to read. Traditional educational research that compares reading methods on the basis of achievement tests has not and could not produce understanding of the learning processes involved. The methods and observations do not yield that type of information. Without systematic methods of experimentation for examining the complex learning, one cannot expect rapid increases in understanding such important types of human behavior. The present results show that actual behaviors and methods of training can be subjected to experimental study. This study by no means completes the task in this area, or even a substantial portion of the task. But it does indicate the possibilities as well as the need for new methods and approaches.

It should be noted that this type of study was made while the children were learning functional reading skills. For one thing, the children in this last study learned to read specific word units that will appear in their early reading training. In addition, the children began to learn some of the reading elements (the letter-sound correspondences) with which they will also be confronted in their early reading training. Even more importantly, the children learned some of the general attentional and discrimination skills that will underlie much of the early reading training they will receive. That is, part of the task of early reading is the discrimination of the letters of the alphabet when presented alone, as well as the discrimination of the letters when presented in combinations. Also, the children must learn that the letters in combination must individually come to control unit vocal responses--and this learning can be considered to have begun in the present procedures. Moreover, it is possible to provide children with functional skills at the same time that the general processes involved are being studied. This demonstration opens for study areas which otherwise would not be a subject of systematic investigation. It is also of significance that although there was a goodly number of training sessions spread over about seven weeks, the total time involved was brief--less than three hours. Again, this result shows that when appropriate training methods are employed, children can learn rapidly cognitive skills important to their further learning. They attend well and make a large number of learning responses in a brief period.

One additional area should be the subject of attention in discussing the results. The findings are important in the area of basic learning theory and the extension of learning theory to a consideration of complex human behavior. Traditional learning theory approaches to language have been criticized for not being able to account for the novelty or originality that is commonly displayed in human behavior. It has been pointed out by Miller, for example, in the context of language development, that, "Since the variety of admissable word combinations is so great, no child could learn them all" (1965, p. 18). The child could not acquire language by learning principles--since the learning task is too large. This criticism of learning approaches has also been leveled by other psycholinguists (Bever, et al., 1965), as though criticizing one learning formulation is like criticizing all learning theories.

Actually, the criticism is well taken and is a challenge which has not been dealt with by those theories. Stated in general terms, the learning theory must indicate how, from training on a finite number of items, the child comes to have a rather infinite repertoire in the area of language as well as in other areas. It should also indicate how the child can "generate" novel responses on which he has not been specifically trained. For it is quite evident that a great deal of originality in behavior occurs on the human level, and this originality must be accounted for.

Staats (1963, 1966, 1968) has suggested some of the learned mechanisms that can account for originality in human behavior through learning. Seemingly a paradox, the way learned behaviors can produce originality becomes clear when one considers the specific stimulus-response mechanisms involved. The present study deals with one of those mechanisms, suggesting that one way that originality occurs is in the production of novel combinations of responses. That is, an act of originality may reside in the fact that a child (or an adult) may make an original combination of responses--one that he has never made before and on which he has received no training. However, the responses that compose the novel whole may have been specifically learned. This mechanism was suggested to account for the types of sentence generation that Miller had described--where the child could not possibly receive training upon each of the sentences he could utter. Thus, as a very simple example, a child could learn to say "man" to an appropriate stimulus, and "running" to an animal running. Upon seeing a man running, however, he could emit the original sentence, "man running."

This mechanism of originality through learning is shown very clearly in the present results. The children never received training in reading the syllables *rab*, *sab*, *tab*, and *pab* or *max*, *sax*, *tax*, and *pax*. They were thus making original verbal responses when they said these "words," elicited by stimulus combinations they had never seen before. The mechanism, in simple terms, was the same as in the above example. Separate stimuli in separate learning circumstances had come to elicit specific responses. Initial consonants in one training situation had come to elicit their individual responses. Then the children were trained also to respond to the stimuli ab and ax in separate learning experiences. When the consonant stimuli were joined with the two syllables, the novel stimulus combinations elicited novel reading responses. This type of mechanism for producing originality in human behavior, and for understanding why the child does not have to have training on everything that he must come to know, has a good deal of generality and significance. In the context of the present concerns, for example, this is one of the mechanisms that underlies what is generally spoken of in reading as "breaking the code." In the present terms the learned skills for breaking the code may be considered as the elementary stimulus-response reading units that the child acquires as a consequence of the training materials with which he is presented. The training materials may be presented in various ways, including the type of concept formation learning task described. The further suggestion of the study, of course, is that the various types of learning involved in breaking the code can be specifically studied in an experimental manner--so the term can become more than a generality. The general suggestion, moreover, is that other learned mechanisms, of which human originality appears to be composed, may also be studied experimentally. Novel combinations of previously learned stimulus-response elements would appear to be one mechanism underlying originality. This type of mechanism should be studied in the context of other kinds of originality.

One final point may be made here, regarding the relationship of learning ability to the child's previous learning of the attentional and work skills. The principles involved have been stated as follows:

> In training situations in which the participation and attention of the child are maintained by positive reinforcers, the requirements for the behavioral output of the child on which reinforcement is based, that is, the difficulty and the length of the task, must be sensitively attuned to (1) the child's work repertoire--that is, his past history of learning with respect to sustaining good work and attentional behaviors as well as to (2) the strength of the reinforcers that are being used. When the reinforcers are lightweight, as in the present case, the training periods must be short and the amount and effort of the behavior demanded must be low. In addition, when working with a very young child the behavioral demands must be minimal and only very gradually increased. The trainer must also be very sensitive to signs that the participation and attentional behavior of the child are weakening. When this occurs, this means that the reinforcement must be increased, or when, as in the present case, this is not desirable, reinforcement should be given for smaller units of behavior. When a weakening in desirable behavior has been detected, the behavioral demands should be markedly reduced until the participation and attentional behaviors increase to good strength (Staats, 1968 a, p. 275).

Evidence in the reading studies is relevant to these principles. In the alphabet training it was shown that the rate of the children's responding increased over the period of training, as the children's attentional and work behaviors were learned. Moreover, it was also shown that the length of the training sessions--which depended upon the quality of the children's work and attentional behavior--also increased over the period of training. In the present study, in addition, it was shown that the ratio of reinforcement per learning response was decreasing. That is, the children made 1.8 times as many responses per token-reinforcer in the word-reading task as they had made in the alphabet-reading task. These results substantiate previous observations and are very suggestive in supporting the principles that have been formulated. Future research will be necessary to further test the principles.

STUDY III: COUNTING LEARNING, AND COUNTING LEARNING MEDIATED BY VERBAL RESPONSE CHAINS

Introduction

Although Thorndike wrote a book on The Psychology of Arithmetic in 1922, it may be said that there have been no learning theory analyses of this type of behavior (with the exception of that by the first author; see Staats, 1963, pp. 219-236; Staats, 1968a), at least in a specific stimulus-response sense. And although there are hundreds of studies of concepts, problem solving, reasoning, verbal response chains (verbal learning), and so on, little attention within traditional experimental psychology has been paid to the actual behaviors that go into human reasoning and conceptual thought. For example, there is little experimental investigation of the learning of mathematical skills.

Piaget has been notable in the field of developmental psychology for working with some of the actual behaviors of mathematics. (It may be suggested that his work will be more valued in future times for this reason, rather than for his theories of cognitive development.) However, his work is guided by his theoretical orientation. Thus, specific stimulus-response learning analyses do not proceed from this work. Moreover, the problems (types of mathematical repertoires) dealt with are not analyzed into their components. The manner in which the skills could be acquired through specific training on the basis of learning principles is not indicated. This is because Piaget has a maturational-mental (cognitive) approach rather than a learning approach. He feels that, although the child interacts with his environment, the child progresses in stages of development which are largely dictated by biological maturation.

Piaget would not accept a view that mathematical development was strictly learned according to the elementary principles of learning. Nor would he accept the directives of, or analyze mathematical development in a manner consonant with, that view. On the other hand, Staats (1963, 1968a) has suggested the skills are learned. It is interesting to note, in this respect, the type of research that has begun to occur as a response to Piaget's work and the question of whether the skills the child has at a certain age are actually learned. For example, a recent study by Gelman (1969) has shown that deficiencies in conservation tests of length, number, mass, and liquid by five-year-old children could be changed by giving the type of discrimination training for numerosity previously suggested (Staats, 1968a, pp. 203-204) and employed in the present study.

The various tasks of Piaget could be subjected to specific stimulus-response analyses and it would then be found that the child could be straightforwardly trained to the skills necessary to solve those tasks. His ability would then be found to be a function of his training, not his age. As one example, take the following statement of Piaget's:

> A child of five or six may readily be taught by his parents to name the numbers from one to 10. If ten stones are laid in a row, he can count them correctly. But if the stones are rearranged in a more complex pattern or piled up, he can no longer count them . . . [H]e has not yet grasped the essential idea of number (1953, p.75).

Staats (1963) has made a specific stimulus-response analysis of the skills that go into being able to count objects in a row, or objects in random order. The analysis straightforwardly stated that the skills would not depend upon the child's age, or upon some nebulous concept of number, but upon the skills that the child has acquired directly through sensory-motor and verbal skill training. Staats tested this learning theory of counting acquisition on his own child and later on other children (Staats, 1968_a_) and found that children much younger than five or six could be trained to such skills. It will serve to summarize this learning theory of the first acquisition of number skills, including the repertoires involved in counting, since it is this learning analysis that serves as the theory for the research that is to follow.

The first acquisition of differential response to numerosity may be considered to be another case of the type of concept formation that has already been described. In any presentation of number there are objects involved. When two oranges are presented to the child and he is prompted to say, "Two," the verbal response will come under the control of the stimuli that are present. Any object is actually a composite of multiple stimuli. Thus, two oranges include the stimuli of size, color, shape, and so on, in addition to the stimuli of number. _Each_ stimulus component will come through the above training to elicit the verbal response. Thus, training trials are also necessary where the child is reinforced for the verbal response only in the presence of "twoness" and not systematically in the presence of the other stimulus attributes that objects have. This additional experience will extinguish the "number" verbal response to the various stimuli specific to the objects involved, and thus bring the number verbal response under the control of "twoness," the stimuli of numerosity.

The training of the "concept" of numerosity must involve numbers other than two objects, of course. Moreover, additional learning must include training to respond to verbal questions of numerosity appropriately:

for example, the child must learn to respond to the numerosity of objects when someone has said, "How many," and not when the person has said, "What color." Staats has shown that training in discriminating by number can begin when the child is only 18 months old. Discriminating and naming small numbers of objects can be complete before the child is two (Staats, 1968a).

To continue, a learning analysis would indicate that this type of number discrimination training can form only a limited "concept of number" in the child. That is, at some point the child is not able to discriminate objects by number through straight discrimination training. As a stimulus, nine objects is not markedly different from 10 objects--certainly none of us could discriminate sets of objects of slightly different numbers past a certain few. To respond differentially to sets of objects on the basis of number requires additional skills that involve counting of some sort.

At a higher level of number skill development, a counting repertoire may also be analyzed into its learned stimulus-response components. It can be seen that counting consists of sensory-motor sequences which occur in conjunction with sequences of verbal responses. The child must look at the objects in a systematic sequence, one by one, from left to right, when they are arranged in series. At the same time the child must make a sequence of verbal responses, the series of vocal number responses of counting, beginning with saying "One." Moreover, these two sequences of skills must be coordinated so that the stimuli produced by one elicit the appropriate response in the other. Thus, there are three types of complex learning that must take place in learning to count. The child has to learn a sequence of sensory-motor responses that involves attending to the individual objects in the set in order (one at a time, at least at the beginning). He also has to learn a sequence of counting verbal responses. In addition, as a third type of learning, the latter has to be under the control of the former and vice versa.

Although this skill includes a sensory-motor sequence and a verbal sequence, it is expedient to conduct the training of the child on the several aspects of the skill simultaneously since they must come to be functionally linked through learning. (Because the nature of the learning has not been analyzed, parents frequently teach the child the non-functional--and actually interfering--verbal responses of counting by themselves.) One way of simplifying the training is to arrange the objects in a series. Then the child can be trained more easily to point at each object in the series in order, moving consistently in one direction. At the same time the child can be trained to make the verbal counting responses in a certain order--one verbal response for each pointing response.

In this training, several skills must be acquired. The child has to acquire the sensory-motor skill and the verbal response sequence, both in the appropriate order. And he has to have the pointing response in each case control the emission of the verbal response--and the verbal response, in turn, must control the next pointing response. In training the child, it will be seen that this coordination may be the last to be firmly learned. The child will first learn to make the verbal number responses either faster or slower than the pointing responses.

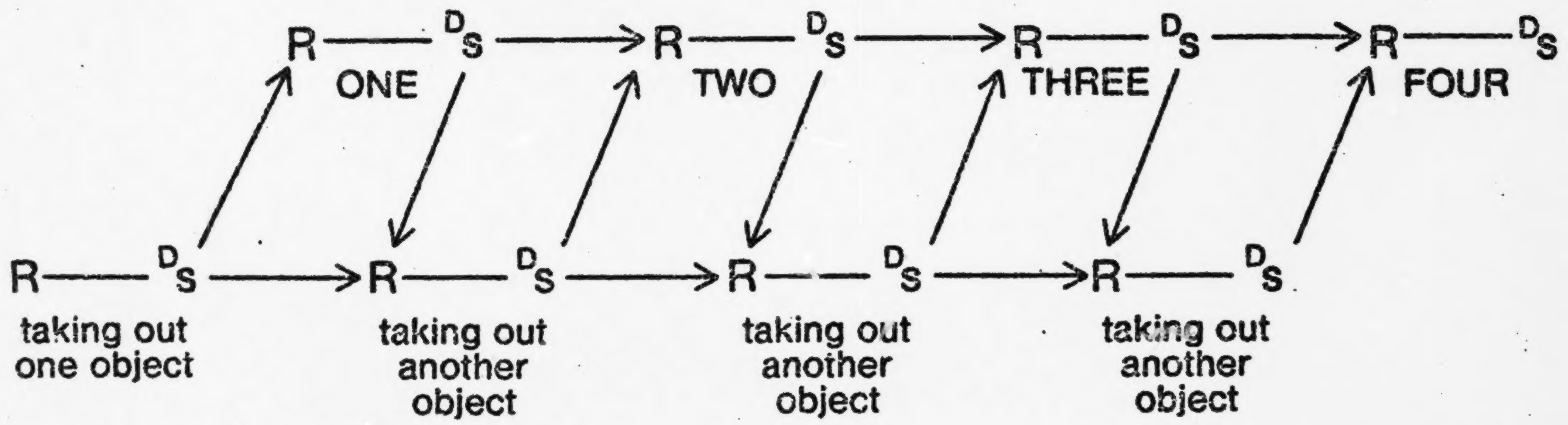
Piaget sees a difference in the mental development of the child who can count objects only when they are arranged in an ordered series and one who can count randomly arranged objects. The latter he would regard as having the concept of number, versus the "mechanical" skill of the former. The results of Staats (see 1968a), however, indicate that there is no difference in principle between these two types of skills. The only difference, in fact, concerns the sensory-motor skill sequence. It is difficult to count a randomly arranged set of objects by pointing to its objects. Since there are no explicit reference points, for example, one may retrace oneself and point to and verbally count an object twice--or one may be missed.

A different sensory-motor sequence is required. A very simple one is to employ an appropriate set of objects like pennies, so the child can place a finger on each penny and remove it from the set. He must then continue to perform a sequence of such sensory-motor responses, moving each object from the original pile over to the newly-formed pile--each time saying one number verbal response--until the objects in the original are exhausted.

When the child has acquired the sequence of sensory-motor responses of withdrawing objects from the set, one at a time, in appropriate association with the number verbal response sequence, then he is able to count any random assortment of objects (up to the limit of his verbal response chain). The totality of the skill as diagramed into stimulus-response components is shown in Figure 10. The diagram is made to indicate the various sources of stimulus control that have to be acquired in the child's training, and to indicate how a complex skill can be seen more clearly when subjected to an S-R analysis.

Place Figure 10 about here

Unlike Piaget's suggestion, there is nothing basically different about counting objects in series or when randomly arranged. It is perhaps a bit more simple to train the child to count ordered sets of objects than those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randomly arranged. However, although there are no precise data to this effect, detailed observations of children in the two learning tasks indicate it would no doubt be possible to train the child to count randomly arranged sets without training him to count ordered sets. In such a case, in fact, the child would then find it immediately more difficult to count a set of objects that were strung out, rather than grouped into a pile. What the child can do in this respect will be a function of his learning history.

The previous results have shown that children, younger than Piaget would expect to display the "concept of number" by counting randomly arranged objects, can be easily trained to do so in a functional manner. This will be demonstrated with two children herein. The purpose, however, of the present study was focally to derive another experimental hypothesis from the theoretical model of counting characterized in Figure 10. As with usual theoretical models, it should be possible to derive implications from the theoretical analysis of counting that can be employed as an experimental hypothesis to direct additional research activities. The hypothesis derived for the present study was that the child's counting, once established in rudimentary form, could be extended simply on the basis of rote verbal learning procedures in which the child learned additional verbal response sequences of counting. Let us say that the child has learned the counting repertoire diagramed in Figure 10 and this repertoire is strongly acquired--that is, the sensory-motor and number verbal response sequences take place invariably in the appropriate manner and they are "coordinated" strongly also. If the child is given one, two, three, or four objects, he will count them correctly. At this point, however, the child still has a restricted counting repertoire. Presented with a problem that involves 10 objects, the child will count up to four, and then he will display incapacity--ordinarily repeating a number already said.

The theoretical model suggests, however, that what the child has learned also involves general control of any particular number verbal response by the sensory-motor response. When the child pulls an object out of the pile, this ~~provides the~~ stimulus for the child to say a number response--any number response. The particular number response is dictated by the previous number response, that is the word association between the two numbers. The child says, "Four" rather than some other number because he has just previously said "Three," (and "One" and "Two" before that), and the stimulus of having said "Three" elicits the saying of "Four." In the other direction, also, it is suggested that the child has learned general skills. The saying of a number response, any number response, provides the controlling stimulus for the motor response of removing the next object--until there are none left. It would be expected on the basis of the theoretical analysis, that if the child was now trained--purely as a verbal, serial learning task--to make additional number verbal responses, this verbal training would extend his functional counting repertoire. Although functional counting is dependent upon the sensory-motor repertoire, and the conjunction of this repertoire with the verbal counting, if the analysis is correct, it should be possible to extend the functional counting skills, once acquired, solely on the basis of additional verbal training. Let us say, as an example, that the child with the counting repertoire shown in Figure 10 was given verbal training in which he acquired the verbal response chain of counting up to 10. That is, the upper sequence of verbal responses in Figure 10 would be extended, with no extensions of the other stimulus-response components that compose the number concept skill of counting. The theoretical model would predict that if the child was then presented with from five to 10 randomly arranged objects, he would now be able to count them--although this would represent an entirely novel behavior, since he would never have counted that many objects before. The rote verbal learning should result in a functional reasoning skill, when introduced at that point of training. In summary, the major hypothesis was that a child who had already learned a counting repertoire of coordinated sensory-motor and verbal number sequences would have this repertoire extended to quantities of objects never before counted, if he was additionally trained only to a verbal response sequence up to the maximum quantity presented. The previous research with one child had provided support for this hypothesis; the present study constituted a more formal test with a group of children.

Method

The same general conditions already described applied in the present study. That is, the same apparatus, facilities, data recording methods, and so on were employed. The experimenter-trainer was the third author.

Subjects

Child 1 and Child 2 were replacements for children who had left in mid-year and were not included in the test of verbal extension of counting. Child 1, who along with Child 3 did not have counting skills, was given training in the skills and produced data on the course of this type of learning when it is begun with no prior training. Thus, nine children served as the subjects in the experiment on the verbal extension of the counting repertoire, and two children's results showed the course of the counting learning when the child has not had prior training.

Verbal and Sensory-Motor Counting Training

In order to test the hypothesis, the nine children had to be first trained to a rudimentary counting repertoire. The children were pretested to ascertain what they could do in the way of counting. Several children had verbal counting skills of varying levels, but could not count objects. Child 3 could count verbally to three, Child 4 could count verbally to four, and Child 8 could count verbally to 14. Several children had functional counting repertoires which included the verbal and sensory-motor components--Child 5 had a repertoire up to four, Child 6 could count to six, Child 7 to six, Child 9 to 14, Child 10 to 13, and Child 11 to 10. (Child 1 had no counting repertoire.)

The pretraining consisted of training the children who did not yet have the skills to count unarranged objects to at least five. The children who could count further to begin with were given additional training to insure that the repertoire was strong when randomly assorted objects were involved.

Verbal Number Sequence Training

The children who had few number or counting repertoires were given the number concept training, beginning with the first discrimination of numerosity and the labeling of one, two, or three objects. In this training, the E-T displayed a card with one or two pictures of objects on it. If there was only one picture, the child would be prompted to say, "One dog," or whatever. If there were two objects on the card the child would be prompted to say, "Two," of whatever was on the card.

When the child could discriminate and correctly label one or two objects, cards were introduced with three objects on them. Additional discrimination training was conducted until the child could correctly label by number the cards whether one, two, or three pictures were on the card. Following this, cards were employed which had one, two, or thee geometric forms on them. The child's task was then to label by number the objects--without including the names of the objects.

When these number responses had been learned, the child was trained to count. First the E-T displayed a two-dot card, covering one of the dots so that the child responded, "One," then uncovering the second dot so that the child responded, "Two." Demonstrating the procedure, the trainer prompted the child to point to each dot in turn saying, "One - two." Using this same method, three and four dot cards were presented.

When a chain of numbers had been established for pointing and counting on the cards, objects (beads, dominoes or pennies) were arranged in a line. The trainer demonstrated pointing to the objects in sequence, left to right, and counting aloud. The child was prompted to do this. Then training was conducted on three objects, presented in an unarranged pile. The trainer demonstrated pulling each object towards him while counting aloud. The child was prompted to count the three objects in this manner. When this pulling over and counting behavior was strong, the counting of four unarranged objects was demonstrated and the child prompted to pull over and count the four objects. Within each session two or three different types of objects were used for counting trials. When the counting of four unarranged objects was strong, counting one more object was trained until the limit of the child's verbal counting sequence was reached, prior to the training on just the verbal portion of the counting repertoire.

Verbal Number Sequence Training

The verbal number sequence training was quite simple. The child was requested to count (verbally only). When he had said the last number response in his already learned sequence, the E-T then said the next number. This stimulus served to elicit the child's imitative vocal response--that is, the child repeated the number. This procedure was repeated until the new number response became part of the child's chain of verbal counting responses. When the child had the new response in the chain so that he made the response without prompting, the E-T would then say the next number when the child had come to the end of his sequence. Then learning trials were conducted on this new number response.

Results

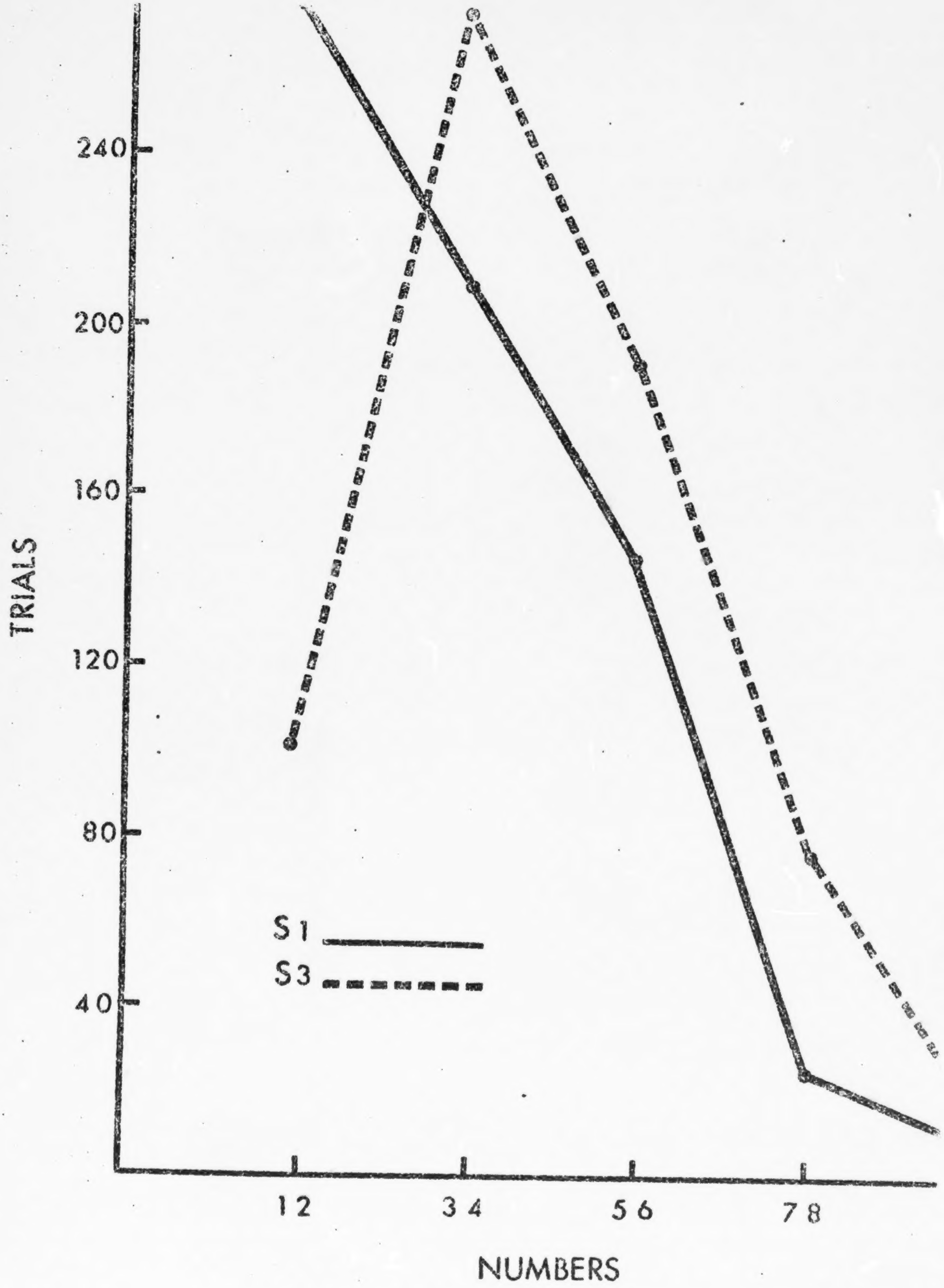
Although it was not the main focus of this study, evidence by the children given the initial number training supported the previous findings (Staats, 1968a). That is, the children could be trained readily, and standardly, to discriminate the stimuli of number and to label the several differing numbers of objects (pictures) correctly. When this repertoire had already been established in the child, counting training proceeded in the manner expected on the basis of the learning analysis. That is, the sensory-motor and verbal sequences of responses, in coordination, could be learned on the basis of the instrumental stimulus-response procedures employing reinforcement. The learning produced functional counting repertoires.

The children were given a mean of 238.4 trials in a mean of 22.66 sessions of counting training prior to the introduction of the straight verbal chain training in counting. The training up to this point established functional counting chains of at least five for those children whose repertoires were not yet this advanced. For the other children the training was employed to consolidate the somewhat spotty learning they had already acquired.

This variability of children's pre-experimental learning did not allow for very systematic study over the group of the effects of the acquisition stages of the first counting learning. The results are quite interesting, however, for the two children who had no number skills to begin with, but who were trained to a counting repertoire up to 10 for the purposes of the study of this form of learning. Child 1 and Child 3 could, at the beginning, count not at all in the first case, and only to three in the second (and this only on a verbal leavel). Both of these children,in learning a functional counting repertoire to 10, showed the learning acceleration that was typical of the alphabet-reading learning. The first numbers learned in the counting task generally required more learning trials than those learned later on. The learning curves of the two children are shown in Figure 11. S_3 required fewer trials to learn to count one or two objects than he did to count three or four. Thereafter the learning acceleration was shown (as it was for S_1 from the beginning). There was some evidence of the same sort in the previous research as well as with some of the other children in the present study. This beginning uneveness in the increasing learning acceleration may be due to the fact that no additional learning is required for the child to count one object. The only learning in counting the first two numbers occurs when there are two objects involved--the children have already been trained to say, "One," to one object. Learning to count three and four objects, however, requires learning for both numbers.

Place Figure 11 about here

At any rate, the results for these two children show a general overall learning acceleration. In conjunction with some of the previously obtained results, this suggests that the learning acceleration occurs also in the realm of early number concept learning. Additional research should be conducted with even younger children to verify this finding. Younger children in not having already learned


240
200
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TRIALS
S1
S3
12
34
56
78
NUMBERS

repertoires, could provide the replication data needed. A sufficient number of children could then be trained to assess statistically the learning acceleration phenomenon.

The other major purpose of the present study was to test the possibility that after the child has acquired a coordinated sensory-motor and verbal sequence of counting, the full counting repertoire could be extended by rote learning extension of the child's verbal counting repertoire. The results in this area are very clear cut, in each of the nine cases where the hypothesis was tested. After the child's verbal counting repertoire had been extended, he was presented with the task of actually counting a set of objects of greater quantity than he had ever counted before, and did so immediately. In each case, the objects were counted without error on first presentation. The child pulled the first object from the pile, said, 'One," and then continued on in the sensory-motor and verbal response sequences without pause. There was no detectable difference between counting on the portion where the child had been trained in both the sensory-motor and verbal skills, and the portion where the child had received only verbal training.

It is interesting to note that it was not necessary to first train the child to a large verbal-sensory-motor counting repertoire before the simple verbal learning training was effective. This possibility was tested with two children, each having learned only to functionally count up to five objects prior to the simple rote verbal learning training. Nevertheless, in one case the child's functional counting repertoire was increased from five to 11 solely on the basis of the rote verbal learning. In the other case the functional counting repertoire was increased from five to 12 on the rote verbal learning basis. Other children had their functional counting repertoires extended on the rote verbal learning basis from seven to 11, from nine to 15, from 10 to 13, from 10 to 15, and three children from 14 to 20. Thus, the length of extension of the counting repertoires through verbal training solely extended variously from three to eight numbers, with children who had prior functional counting repertoires that varied from five to 14.

The mean time spent by the children in the aspects of the number concept learning described herein was three hours and 19.6 minutes, in a mean of 37 training sessions. The mean length of training session was 5.4 minutes. During the total training the children made a mean of 1,630.1 responses and earned a mean of 374 token-reinforcers. The mean ratio of reinforcers to responses made by the children was one to 4.4.

Discussion

The observations of the children's behavior in the present number concept learning supported the previous findings. Stimulus-response training materials and procedures utilizing a token-reinforcer system may be successfully employed to train preschool children in functional number skills. Their attentional and work behaviors were maintained in good strength throughout the task that involved arduous and repetitive learning tasks. Essentially, the procedures consisted of the presentation of new stimuli while the children were prompted to make the various responses. The stimuli came to elicit the complex configurations of responses the S-R analysis indicated were necessary in learning the skill. The elicitation of the complex response sequences constituted the functional skills the children had acquired. The various children in the sample learned in this stimulus-response manner the functional skills of counting, although they commenced the task with varying levels of skill. These results are straightforward and may be taken as verification of the S-R analyses of these aspects of number concept learning, at least in a preliminary manner. This is not to say the analyses have been worked out in their ultimate detail, or that the empirical data cannot be improved in detail and form. In principle, however, the stimulus-response analysis may be considered to receive support when training based upon the analysis produces the behavior in the manner hypothesized. More will be said later on this topic. The general point here is that the explication of the learning conditions necessary to produce the behavior takes the behavior under consideration out of the realm of maturation and into the realm of learning.

The suggestive evidence that there was a learning acceleration in the two children who were subject to the whole number concept training has considerable significance. If this finding is corroborated with additional cases in studies set up specifically for this purpose it will add a good deal to the generality of the learning acceleration phenomenon in cognitive learning. It is important to begin to establish how general the effects of learning are upon the acceleration of the learning rate in the child's cognitive development, as well as his development in other important areas of behavior.

The other major point of the present study, however, was to test the hyposthesis that once the child has acquired a rudimentary functional counting repertoire, it may be extended merely by further rote verbal training in counting. Nine children were given such rote verbal learning experience, and in each case the verbal learning mediated the novel counting of greater quantities of objects than the child had previously encountered.

The latter results have several implications. First, the present findings are novel in showing an important function of verbal response sequences; that is, of rote verbal learning. Actually hundreds of studies of rote verbal learning of the paired associate and serial learning variety have been inducted. We know very well that humans can acquire extensive repertoires of word associations. However, this type of research has moved almost completely in the direction of studying in greater detail the minutiae involved in the process, without any further understanding of significant human behaviors being produced. It is necessary to break out of this tradition and to begin to study the relevance, the function, of such verbal sequences in the context of significant human behaviors.

Staats (see Staats, 1963, 1968a, in press b) has suggested that verbal sequences (word association chains) are important to various aspects of mathematical reasoning (as well as other types of reasoning). The present study verifies this analysis in the realm of a beginning aspect of mathematical learning--the acquisition of counting skills. The results actually show how the child's previously learned language--his ability to imitate words--can be employed in training him in the further acquisition of verbal response chains. The learning and the verbal number sequences that result, in conjunction with the other counting skills, provide an expanded number concept--that is, an expanded ability to solve relevant number problems.

The present study demonstrated another mechanism that can be important in producing originality through learning. In the present example, the children had not been trained to count objects above a certain number. Nevertheless, when through rote verbal learning procedures they were trained to the verbal counting sequence, when presented with a novel counting problem (novel stimulus situation) the verbal sequence was elicited, and it mediated the appropriate, original, counting behavior. The findings indicate the manner in which a verbal response sequence, learned under a set of circumstances disconnected from actual stimulus objects of the world, can nevertheless mediate behaviors to the objects of the world that the individual has never had a direct opportunity to learn. In general terms, the individual's language behavior, which could be learned in any type of pure verbal situation--reading, discussion, rumination, and so on--can be an important mechanism that determines how the individual will respond to the actual environment. This is one example of how one's language behaviors can affect his other non-verbal behaviors--in fact, this is one of the powerful functions of language. It may be noted that this function of language includes that of generating novel behaviors.

Important possibilities for additional experimental study of the principles involved exist in this area. Study of other skills that appear to be learned in this manner would be relevant. The paradigm would be to give subjects experience with some set of stimulus objects to acquire a basic set of interrelated skills, including verbal skills. Then the verbal aspects of the skills would be elaborated in separate training. Later, the effects of the verbal training upon the other aspects of the behavior would be studied. Staats (1968_a_, pp. 177-178) has suggested that certain scientific discoveries involve such a paradigm--for example, the function of the periodic table of elements in promoting the search for elements that were as yet undiscovered. The use of literal numbers in algebra seems to have a similar function. In a simpler example, the possibility that other mathematical skills involve this type of mechanism could be studied experimentally. Perhaps the mechanism functions in the realm of number operations such as addition. That is, the child could first be trained in combining two sets of objects and then counting the combination--the basic operation of addition. He could be trained to bring together two sets of two objects and at the same time say, "Two plus two are four." After having done this to a number of problems, could the child's adding repertoire be extended simply on the verbal level in learning the addition tables by rote? The learning analyses would suggest this possibility, and naturalistic observations support the hypothesis.

In the context of discussing rote verbal learning, several additional points should be made. Critics of traditional learning approaches have complained many times about rote learning methods, implying (albeit vaguely) that there is more to the acquisition of functional cognitive skills than rote verbal learning. The criticism is well taken and does indicate a weakness of traditional learning approaches, although no solution is suggested. The question remains concerning what rote learning is, in any case, versus "meaningful" learning. If one trains the child to rote verbal counting responses--so that he can on request say, "One, two, three," and so on--the child will not have a functional counting repertoire on that basis alone. Presented with various number and counting problems, he will not be able to respond appropriately. Thus, when one begins by training the child to the verbal counting, without the other elements, the skills acquired are non-functional--that is, "rote." Moreover, the verbal skills acquired at this stage of the learning task will actually be inhibitory. That is, once the child has learned to "rattle off" a non-functional set of verbal counting responses, it becomes more difficult to train him to coordinate his verbal responses to his sensory-motor counting responses. Thus, the same learning of rote verbal sequences of counting may be inhibitory at one time, and at another time, after the child had learned functional counting skills, may be functional. Only a specific S-R analysis of the set of skills involved can indicate the respective effects of the rote verbal learning.

One is open to the challenge of "rote" learning in the pejorative sense when one has made an incomplete analysis of a particular type of behavioral skill, and then bases one's training procedures upon that incomplete analysis. The fact of the matter is that there are many "rote" training procedures in this sense--and their use is not limited to learning theorists. A child who is trained only to read a limited number of words for meaning certainly does not have a functional reading repertoire. This is the case also if he learns only the alphabet, only a repertoire of reading units for sounding out words, and so on. Reading consists of a complex of skilled repertoires. Each repertoire by itself is insufficient.

The same is true of most complex human behaviors. As suggested above, being able to say the numbers in order does not constitute a counting repertoire. The verbal number sequence is an important part of the counting repertoire, but only a part. The sensory-motor skills of taking objects out of a randomly assorted pile is also an important part of the counting repertoire,but still only a part. In fact, by itself, it is only a sensory-motor skill of limited significance. When the two repertoires are suitably conjoined through learning, however, they constitute important components in counting skills and in the more general concept of number. Even when so conjoined, however, other skills are required to form the complete counting repertoire, and more, to form the more complete concept of number. Nevertheless, one should not lose sight of the importance of each behavioral constitutent to a more complex repertoire of skills. The present study indicates this by focusing on the number verbal resppnse sequence acquired on the basis of rote verbal learning procedures. The same importance is true of every behavioral component of a more complex skill. When one is interested in a theory that explains a particular complex human behavior, he must be prepared to analyze the behavior into its stimulus-response constituents.

The relevance of the present conception and supporting evidence for other conceptions of the child's development of number concepts should be indicated. Maturational development has traditionally received heavy stress as a supposed determinant of number concept development. The concept of readiness, for example, has been influential in educational circles. In the field of child psychology, Piaget has offered a developmental conception which has great contemporary influence. He suggests very strongly a heavy biological determination of cognitive development. He states: "It is a great mistake to suppose that a child acquires the notion of number and other mathematical concepts just from teaching" (1953, p. 74). Rather, the child is seen to be "ready" for the development of number concepts when his mental structures have developed to the point where he can grasp the principle of conservation of quantity. Conservation is shown by the child's ability to recognize invariance of a specific quantity through various rearrangements of other variables.

It may be hypothesized, in contrast, that this conservation of quantity is strictly learned--and consists of various skilled repertoires that have been conjoined through learning into more complex, functional repertoires of skill. The child has to learn to respond to the stimulus of quantity in and of itself, and not respond to other stimulus features of the objects. This involves the type of discrimination (concept formation) that has already been discussed. That is, as described, at the first level of the child's number concept learning he has to be able to discriminate simple sets of objects by number, which means not responding to the objects on the basis of size, shape, color, and so on. As one example, the child has to learn to say, "Three" under the control of the numerosity stimuli of threeness, even though the objects involved vary widely on various dimensions. This skill cannot be acquired through one trial where the child is reinforced for saying "Three" while looking at three oranges, because the size, shape, and color of the objects are also stimuli that will through this experience come to control the response. The only way to train the child to this beginning "invariance" (conservation of quantity) is to have additional trials with objects that have varying irrelevant stimulus features, while holding invariant the one stimulus property that must come to control the number response. The child's invariance of response to number (conservation of number) in this situation depends upon the "invariance" properties of his training. This process can be seen clearly in training the young child who has learned no appropriate response to number--as was the case with several children in the present study.

Piaget has suggested that the inability of the child to count differently arranged quantities of objects shows the child's lack of conservation of quantity--and thus his lack of readiness for further mathematical training. The lack of such conservation of quantity may be considered in the same terms employed for the child's first discriminations of quantity. When a child is trained to count a set of objects, the specific conditions involved must be considered in their roles as stimuli. Quantity is one type of stimulus. However, the kind of object, as has been indicated, presents stimulus conditions--again of size, shape, color, and so on. When the behavior is reinforced in the presence of these stimuli, they also gain control of the response. The arrangement of the objects constitutes another stimulus property that will gain control of the child's response. Arrangement is of focal importance in learning to count, for the sensory-motor skill aspect of the counting must vary, depending upon the arrangement stimulus features. When the child has learned, for example, through his training, to point successively to each object arranged in a series, his pointing sensory-motor skills will come under the control of the arrangement stimulus characteristics. If the child is then presented with a set of objects arranged in the form of a cross, or a circle, or some other form, his counting will break down--because his skills are no longer appropriate for the arrangement of the stimulus objects. Considering the number of objects invariant in number, without considering the invariance of arrangement, makes no sense unless the child has been trained to appropriate skills for the various arrangements. If one wishes the child's counting repertoire to apply to many different situations, one must provide training that will elicit the necessary repertoires in the face of varying stimulus conditions. (The child, however, does not require training in each and every minor varying condition. After receiving training on a certain number of arrangements, he will have acquired skills largely under the control of the quantity stimuli and will make appropriate responses even with new situations.)

As Piaget has said, a child trained to count objects in series will not be able to count randomly arranged objects. Different sensory-motor skills are necessary to count randomly arranged objects than objects in series. However, children down to the age of two can be readily and straightforwardly trained to this aspect of the conservation of quantity. It is not necessary to await some inferred maturational process to make the child ready. His readiness is a function of his training and his resultant skills.

Learning analyses in stimulus-response terms, it is suggested, would reveal the other skills of which Piagetian concepts of conservation are actually composed.

It may be suggested, in concluding the discussion of the present findings, that traditional developmental methods of study are not adequate for attaining knowledge of the determinants of the child's behavior advancement. These observations are of the behavior of the child itself--not of any independent events that might affect that behavior. They do not include observations of possible biological determinants, nor of possible learning determinants. This is true of developmental observations of a longitudinal nature, of a cross-sectional nature (as in tests also), or what have you. This includes Piaget's observations. While interesting, important behaviors are many times observed, no observations are made of the possible causes of the behaviors. Because Piaget, as an example, has not observed the learning events that bring about the child's developing cognitive skills, he reaches inappropriate conceptual conclusions. The underlying conception is that the child's behavioral advancement is due in large part, at least, to an unspecified maturational unfolding. A related conclusion is that there is universality to the observations made--that is, that children in general will develop that way. There is no deep conviction that the child's behavioral development is relative to the type of training he has received. In contrast, it may be suggested that while the type of training may be general across a cultural grouping, and give the appearance of some universality, if the behaviors are learned, the behavioral development is relative to those cultural training practices. From this standpoint norms of behavior development are not seen as necessarily reflecting general processes. Whether or not any behavior is learned, according to stipulable training, must be subjected to direct analysis and experimentation.

Thus, a quite different view emerges from the employment of basic learning principles in the consideration of the learning events that effect child behavior development. When one observes systematically and experimentally the learning experiences of the child, (where learning conditions are purposefully manipulated)--even in the naturalistic situation--the learning elements become clearly evident. When this type of study is conducted, the overwhelming role of basic learning principles and the specific conditions of learning can be seen. To recognize the importance of learning in any repertoire of skills of the child, it is necessary to analyze the performance of the skill into its stimulus-response elements. When the stimuli that control the responses are isolated, it is then a short step to observe the acquisition of the skill and to begin the development of procedures to produce the skill. More will be said of this later.

It should be noted that nine of the children participated in additional types of training (subjects S_3 through S_{11}). First, they were given training in reading the numbers from one to 10, using the type of procedure and materials employed in the alphabet reading training. The children received a mean of 1,221.8 training trials on this material. Seven of the children acquired a complete number reading repertoire in this period. Two children (S_3 and S_4) learned to read the numbers only through the number seven.

This training was given to the children to prepare them for exploratory research on learning number operations, beginning with addition. However, only five of the children (S_5, S_6, S_8, S_9, and S_{10}) completed the number reading training with sufficient time left to participate in the exploratory research in addition, and only three of these completed the addition training (S_6, S_8, and S_{10}). After these children could read the numbers in primary type to criterion, they were trained to read the words and and are in the sentence "Two and eight are 10." Then they were presented with more extensive training in addition sequences. That is, they were presented with four addition statements beginning with "One and one are two," and progressing to "One and four are five." The next set of four cards began with the number 2 and made the same progression to "Two and four are six." The next set began with three and the next with four, in each case with the same addenda. When the children had completed each of the four sets of four cards to the learning criterion, the training was repeated again. After the first trial on any set of additions the answer (sum) was covered until the child was given time to respond without prompting. If he did not respond, the answer would be uncovered and he would read the number. After the child had learned the cards in sequence to criterion, they were ordered differently.

The children made a mean of 1,865.8 learning trials in this training. A mean of 74.2 sessions was involved for a mean total of five hours and 15.6 minutes. The children had not attained an errorless performance by this time, but were close to this type of performance. The results showed that the preschool children could be trained in this type of sequence of verbal addition responses in the stimulus-response (rote) learning procedures involving the token-reinforcer system.

The addition skills in which the children were trained were rote, in the pejorative sense. The other skills that go to make up an addition repertoire were not dealt with. There are several repertoires involved in fully functional addition skills--as there are in counting--besides the reading of numbers and the rote learning of verbal addition sequences. However, S-R analyses of these skills--as well as of other operations such as multiplication--have been made, at least in part (see Staats, 1963, 1968a). The study of number concept skills must be conducted beginning, as in the present study, with the most simple skills and advancing on to the more complex, which are additions to the simpler skills. This study must always progress with explicit S-R analyses and empirical tests of the theoretical analyses. When we have records of how specific training produces such cognitive skills, even on a purely descriptive level, it will constitute evidence that through explicit learning experiences cognitive development occurs.

While the present exploratory procedures with addition produced only parts of the addition repertoire, these number reading and addition verbal sequences are essential constituents to a full adding repertoire. The results suggest that it would be possible through the specific training to produce in preschool children (of even younger ages) fully functional skills--at the same time that these learning processes were subject to detailed study, where every stimulus and every response was recorded. The present exploratory work suggests a clear method and the possibility of a good deal of experimental extension.

STUDY IV: WRITING LEARNING, IMITATION, AND THE COGNITIVE LEARNING ACCELERATION

Staats (1963, 1968a) has described what is called imitation or modeling as consisting of several aspects or repertoires that are acquired and that function according to the principles of learning. One of the important aspects of imitation is the acquisition of the sensory-motor skills of imitation and of the stimulus control of those sensory-motor skills. Imitation of the stimulus of someone else's complex act requires not only that the stimulus has come to elicit imitational responding in general, but also that the imitator has acquired the specific complex act in his own repertoire.

Imitational skills are of prime importance in understanding language and cognitive learning, including the topic to be dealt with herein: reading. Many new words (new combinations of already learned phonemes or syllables) are learned by the child through imitation. For example, in many cases the model will say a new word while the child looks at the actual object. The child who has had the appropriate past training will then imitate the word presented by the model. The circumstance constitutes an instrumental discrimination learning trial in which the new verbal response has occurred in the presence of the object stimulus. The child, in this manner, learns both the skill of saying a new combination of phonemes (unit verbal responses), and the new response comes under appropriate stimulus control.

The study of imitation should thus involve the investigation of the original acquisition of the sensory-motor skills of imitation. An extensive learning process is involved in the child's coming to be able to imitate sounds (make verbal responses) that match the sounds made by someone else. The study of imitation also involves understanding what stimuli will come to elicit the imitation responses, and the manner in which the imitation produces new learning. The study of what has come to be called modeling is almost entirely the latter, of how a child can learn through imitation--not how he learns to imitate. Very few studies have taken the original learning of a complex imitation repertoire as the subject matter.

The example of language learning through imitation was given above in part because it can be employed to explicate the type of repertoire to be dealt with in the present study. That is, the learning of writing (copying) is actually the learning of an original imitation repertoire. This is the case, for example, where there is a stimulus produced by another person--the standard stimulus or model. The child must learn a response that produces a stimulus that matches the standard or model stimulus. The standard stimulus may be considered to be a discriminative stimulus. The discriminative stimulus will come to control a response that is reinforced as the child looks at it.

This is the task considered in terms of the general learning principle. In addition, however, there are other aspects of the training that must be considered. In discussing the manner in which the child learns a repertoire of vocal responding and imitation, Staats (1963, pp. 120-121) indicated that the learning gradually increases in precision--at least under salubrious conditions where the standards of training are gradually raised. The adept trainer at first will reinforce the young child for a rather "sloppy" imitation when the child is learning a new response. Later, as the child's skill in making the response increases, the trainer may raise his standards. When a response is given that for that stage of learning is sloppy, the trainer may demand another trial--immediately reinforcing better responses.

The same should pertain to the learning of the imitation repertoire of writing. The task should be so arranged that it requires less skill at first, with increasing demands made as the training progresses. This may be accomplished in several ways, as will be described in the Methods section. In brief, stimuli to be imitated (copied) at first can be made relatively easy, until skill is acquired, and then increased in difficulty. The trainer can, as in the above example, gradually raise his standards with respect to what constitutes a good response for the child, on the basis of the precision with which the child's imitation response matches the standard stimulus.

In the example of language learning through imitation given at the beginning of this section, the manner in which the imitation repertoire could function in the further language learning of the child was illustrated. The imitation (standard) stimulus served to elicit the child's unit verbal responses in a new combination that formed a new word response. This was done in the presence of a new stimulus (an object or event), and the control of the word response was transferred to the new stimulus. (This process has been called higher-order instrumental conditioning by Staats, 1968a, p. 93). This example shows one type of functional importance of imitation. On the basis of the imitation repertoire, the child can learn new cognitive skills. At any rate, a similar type of learning is necessary in writing training to produce a writing repertoire that is independent of the model stimulus. As in language, we wish to train the child not only to imitate, but also to have the skill of writing under the control of other stimuli than those involved in imitation. A child who could only write letters when shown a model would not have a functional writing repertoire.

The task is the same as the one involved in the vocal language example. The child should not only be able to copy (imitate) letters; he must also learn to write them "on command"--that is, under the control of auditorily presented verbal stimuli, including his own self-instructions. To produce independent writing skills, once the child has learned to make the writing response under the control of the model stimulus, the new stimulus that is to come to control the response is presented in contiguity with the model. The writing response will thus come under the control of the new stimulus. In the present case, the experimenter-trainer said the name of the letter the child was imitating (copying) as the model stimulus elicited the imitational response. It was expected that the control of the writing response would come under the control of the auditory stimulus of the experimenter-trainer saying the letter.

The foregoing was the stimulus-response learning analysis made of the task of learning to write letters. The data of the study conducted included the qualitative records of the children's progress in the acquisition of the important and complex sensory-motor skill of writing letters under the control of visual imitation stimuli as well as vocal (auditory) stimuli. In addition, the records of the learning trials involved in the acquisition of the writing repertoire enabled the form of the learning to be described and its statistical reliability assessed.

Method

Subjects

Twelve children from culturally-deprived homes were subjects in this study. They ranged in age from three years and 10 months to four years and nine months. The mean age was four years and four months. Seven of the children had Negro parents, one had white and Negro parents, one, white and Polynesian, and three, white parents. One child had been diagnosed as emotionally disturbed with probable brain damage and was a severe behavior problem. Two other children, one of whom went into comatose states when unhappy, had mild behavior problems. The IQs of the children ranged from 88 to 130, with a mean of 101.9.

The children were enrolled for a preschool program in a regular elementary school (Franklin School, Madison, Wisconsin). The subjects were obtained for the study by contacting the parents of older siblings already enrolled in the elementary school. The preschool followed the regular school schedule, but was conducted only a half day.

Apparatus

The same apparatus was used as for the subjects in the Hawaii study.

Token-Reinforcer System

The same general reinforcement conditions and procedures were also employed, with one difference. In the Hawaii study, the children received intermittent reinforcement for their responses after the training was under way. The present children received reinforcement for every completed response or series of responses and, thus, were more nearly on a continuous reinforcement schedule.

The Laboratory-Classroom Complex

Functionally, the complex employed in the Wisconsin study was very similar to that already described. The children participated in a preschool classroom (which was a large classroom in a three-story elementary school building). They had to walk down the hall to their experimental workrooms where the apparatus was located. Two pieces of apparatus were located in one room and another piece in a separate room.

The activities in the preschool classroom were like those in the Hawaii study. The children's schedule was the same type.

Experimenter-Trainer

The experimenter-trainer (Joan Jacobson) was also a graduate assistant in her first year of graduate school. The training was conducted under the supervision of the first author.

Stimulus Materials for Letter-Writing Training

The materials were of several types. Prior to the introduction of letter-writing training, the children were given training on tracing lines. The lines were ditto-duplicated on 8½" x 11" sheets of paper and consisted of circles, lines, curves, and so on.

In addition, there were ditto-duplicated sheets with the single letters of the lower-case alphabet printed in pencil-thick lines either in two-inch or in one-inch size, or in primary type. Duplicated sheets with increasingly long sequences of the letters, beginning with a, b, and ranging through the complete alphabet were also used. These sequences were printed in primary-size type.

Writing Training Procedures

In the first session, the child was introduced to the use of the marble token reinforcers in the manner already described, employing the picture-naming task. Following the introduction, writing training was commenced. The child was given a black crayon and asked to write any letters he knew. Then he was asked to write his name. None of the children displayed any skill in writing. The child was then given instruction in holding the crayon and drawing lines. He was given a sheet of paper with a line on it and shown how to trace on the line. He was then given trials in tracing. After a number of these tracing trials, during which he learned to hold his crayon and write with it, he was introduced to the letter a in the large size. He was then given trials on tracing this letter. Then he was given a sheet with a large letter a on it, asked to copy the letter, and instructed what to do. Following training on this, a medium-sized letter was introduced and the child was trained in copying this. Later, the primary-sized a was introduced as the model stimulus and copying trials were given.

Each time the child was given the letter to copy he was instructed to copy the a. This was done for all the letters. After the trials in copying the letter a, the child was given a blank sheet of paper and asked to write the letter a. At this point, the various types of training trials were continued until the child had attained some proficiency in copying and writing the first letter of the alphabet. Then the letter b was introduced and the child was given a few tracing trials (on the large-sized letter). Following this, he was given additional trials in copying both the letters in sequence, first in large size, then medium size, and finally primary-sized print. This procedure was followed whenever a new letter was introduced. Learning trials were continued on the new letter, as well as all the preceding letters, until the experimenter-trainer decided that the child had learned to write the new letter to a sufficient degree of skill to introduce the next letter. The standard of skill was an increasing one since the child's general level of writing skill increased in several dimensions. One of the skills involved was being able to write the letter with no visual model stimulus, simply on the basis of the auditory stimulus of instructions. The child continued to receive training on all the letters that he had already learned to write. It should be noted that after the child had learned to write the letter d, the crayon pencil was exchanged for a regular lead pencil.

The earlier studies with the first author's daughter had shown that the child could also learn to write the alphabet under the control of her own verbal responses. After she had learned several letters, she was also trained to say the letters herself as she wrote them. The children through this training, also learned to say and write the alphabet under the control of their own pronounciations of the letters.

Results and Conclusions

There are two types of results. One may be considered to be qualitative in nature. These results consist of the effects of the training on the children's ability to acquire the sensory-motor skills of writing, as shown by the products of their writing. The other kind of result concerns the record of the number of training trials required for the child to attain an acceptable level of letter-writing for each letter. These data then provide a means by which to test the hypothesis concerning learning acceleration through training.

With respect to the second type of result, it should be noted that the learning for two of the children will not be considered with the results of the others. For these two children, the materials and training procedures did not appear to be appropriate. Progress was not being made in a standard manner and the task was revised to emphasize the beginning aspects of the training and to progress more gradually. In this effort, various techniques were tried which make the results too unsystematic to report. One of the two children, however, was beginning to profit from the training and was learning to write more rapidly. He had a repertoire that extended from a to e, but the learning was not yet completed even for these five letters. The other child could copy the letters a through d on command and could independently write a, b, and c.

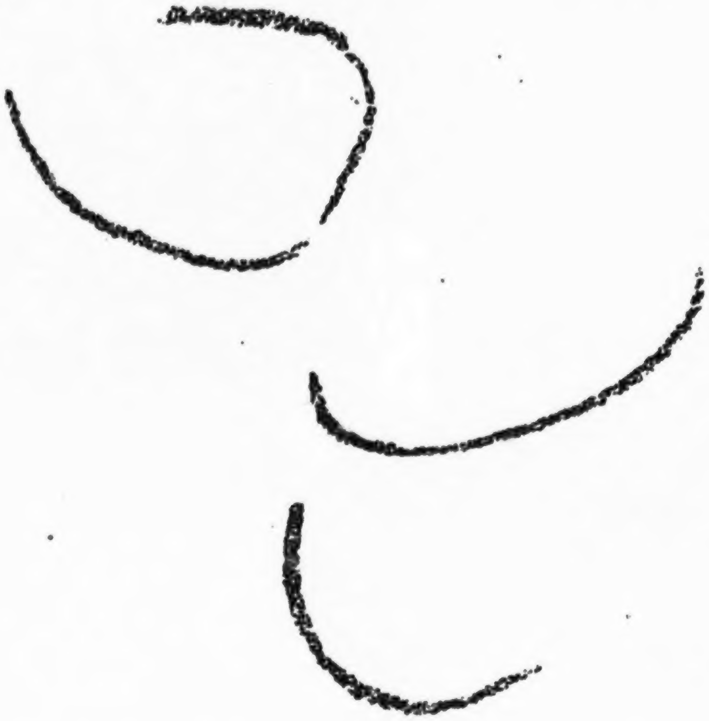
The other 10 children received standard training and rather uniformly learned the skills that have been described--writing the letters under imitative control and under the control of the letters given vocally. In general, the progress of this type of learning may be described as one in which the children had minimal skill to begin with. With one or two exceptions, they did not hold the pencil adroitly; they could not trace or copy well. None of the children had the sensory-motor skills of writing letters to a model stimulus or to vocal command. Moreover, it took a number of training trials for them to acquire such skills. At the beginning, they were able to imitate only the larger letter stimuli. At this point their writing responses generally were large also, and not well controlled. As training proceeded, however, it was possible to decrease the size of the controlling model stimulus. The size of the children's writing also became smaller and better controlled. It was apparent in observing them that their attentional responses improved and they inspected the letters more closely when they were introduced.

It is impossible to present in toto the graphic record for even one child, since five hundred to a thousand responses were made in each case. An idea of the progressive increase in skill, however, may be gotten by sampling the children's records which show a similar progression. A typical record is presented in Figure 12. The response numbered 1 is that given to the request to write the letters of the child's name. Response 2 is the first tracing of the letter a. The sensory-motor imitational response, even when the task is to write on top of the model stimulus, is quite poor, and this is after 178 training trials on tracing. Response 3 (the 228th learning trial) is the first copying of the large a stimulus; the next response (246th) is the first copying of a middle-sized a, and the next (263rd), the first copying of a primary-sized a. The increase in skill is seen here, even in the face of the decreasing size of the model stimulus. Response 6 (426th) is the first writing trial where there is no model stimulus to imitate. It is evident, nevertheless, that the orally-given stimulus to write a has already gained some control over the letter-writing response. The child attempts to write the letter, but does so upside down and backwards. This type of reversal by a child is usually thought to reflect some perceptual disorder or immaturity. It can be seen here simply as incomplete sensory-motor training which is corrected by additional instrumental discrimination training. Similar reversals were common between b and d, for example, but these also disappeared with additional training. Response 7 (473rd) is the child's first attempt to copy a and b in sequence, using primary type. It is clear that the writing responses at this point are not very precise. This imprecision is continued in response 8 (485th), which is the first writing of the two letters without the model.

Place Figure 12 about here

Responses 9 (574th) and 10 (583rd) are reduced in size by one-half and do not show a great deal of improvement yet. These trials involve the first copying and free writing of a to d. It should be noted that the child had already shown improvement on her general writing skills; but samples that take the first introduction of a new letter do not evidence completely the improvement. These trials actually measure general increase in writing skills. By response 11 (641st), nevertheless, there is considerable gain in skill for the first copying of f in sequence.

1



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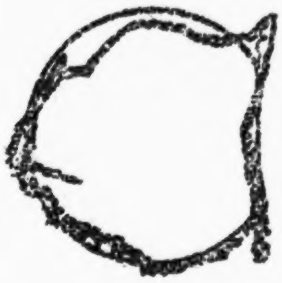

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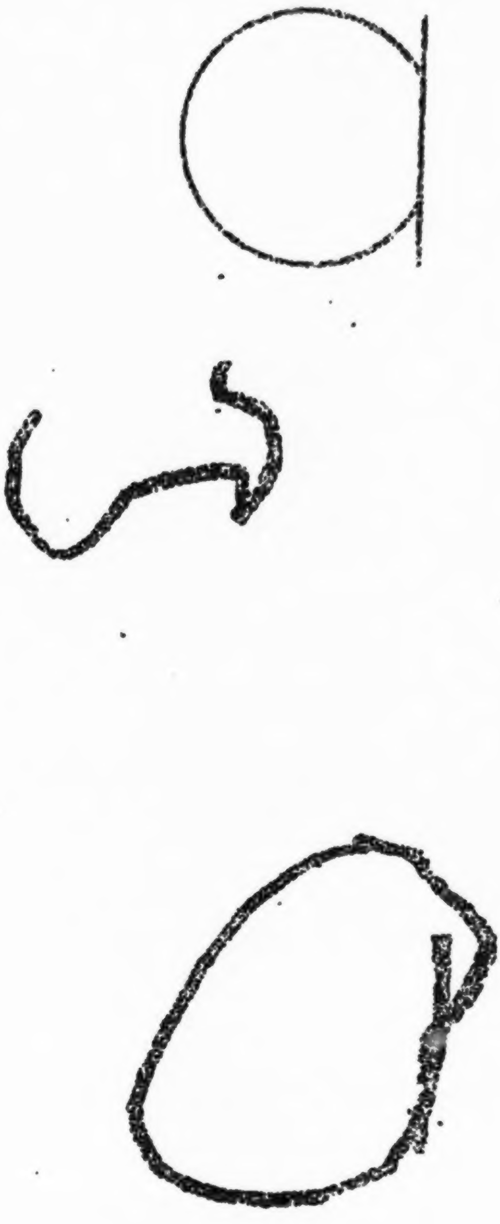

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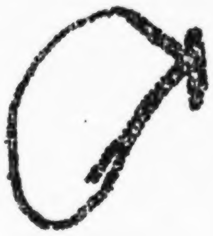

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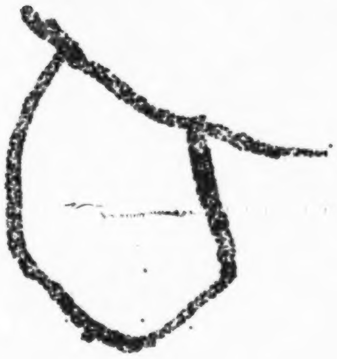

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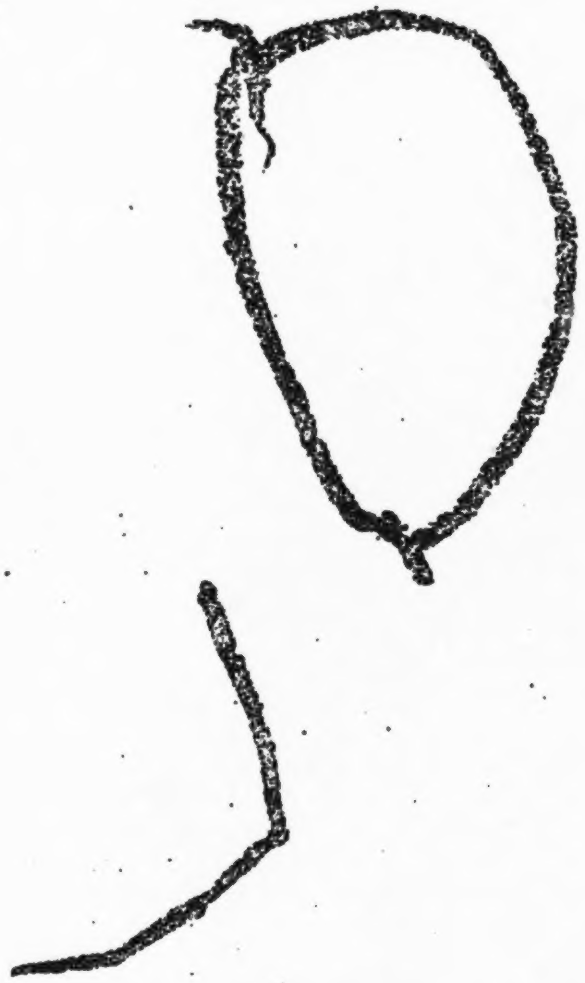
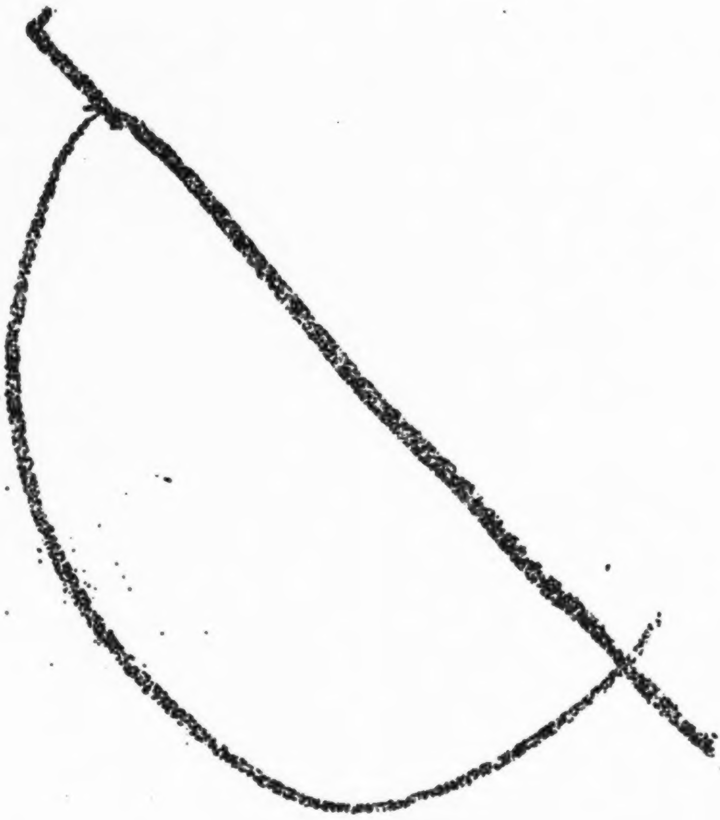
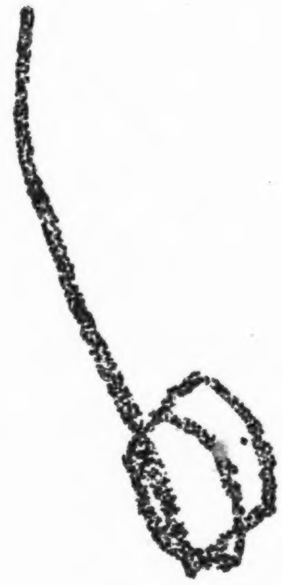


7 a b





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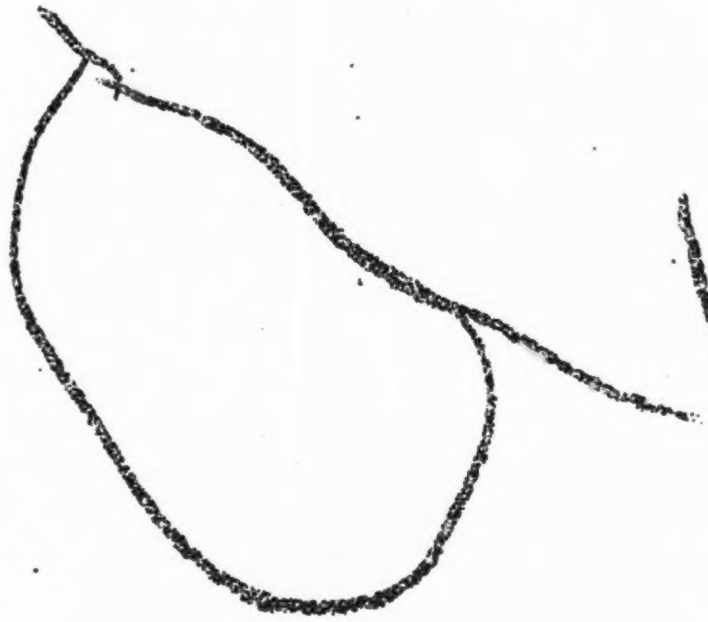
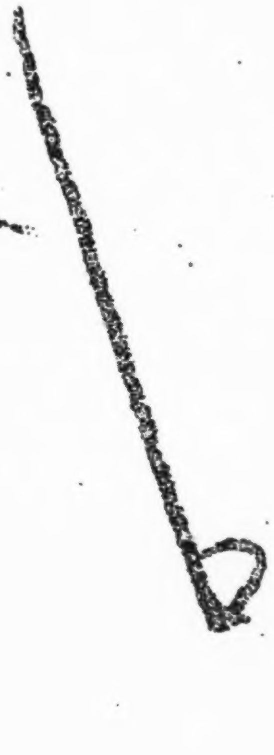




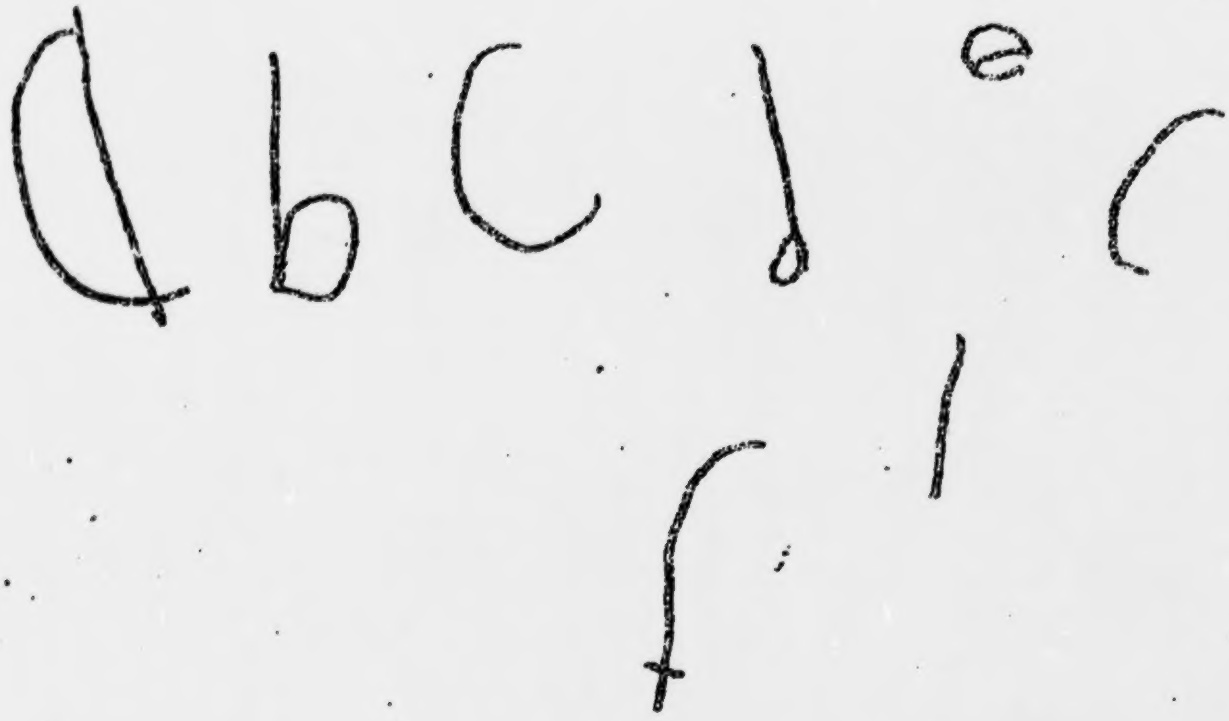
***9**

a b c d

***10**

11

a b c d e f



12 a b c d e

e

b f f

13 a b c d e f g h

a b c d e g

f h

14

a b c d e f g h

15

a b c d e f g

a b c d e f g g

h i j k l m n

h i j k l m n

16 a b c d E f g h i j k l r

n

17

abcdefghijklmnc

prstuvw

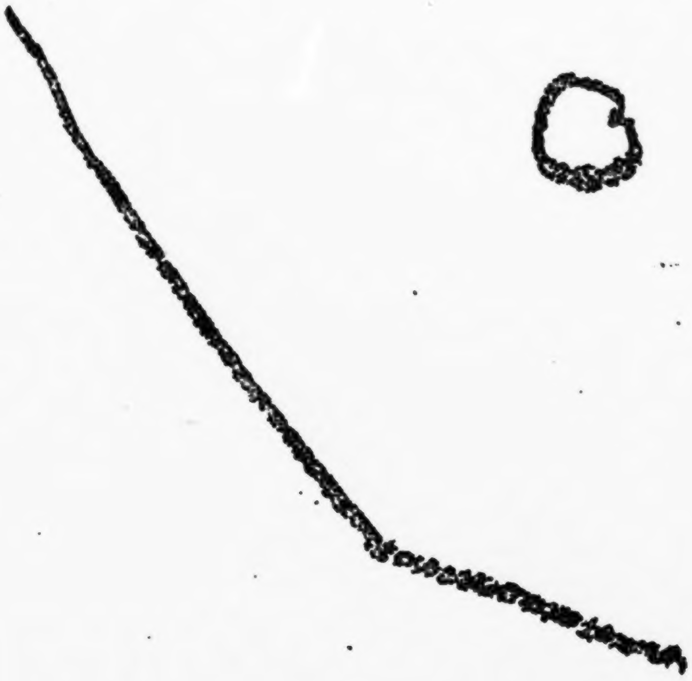
Response 12 (647th) shows that the child's ability to write the letters in sequence is still not good. The letters are too large for the space and instead of creating rows, she writes them diagonally. This difficulty continues in response 13 (647th), although there is evident increase in the writing of individual letters, and in response 14 (681st), where the sequence is written without a model. By response 15 (786th) the child's general as well as specific imitation writing skill has improved markedly. This is the first trial where the sequence has included the letter n. Nevertheless, the letter n is imitated well and in a small size. In the free writing of response 16 (788th), the n is again written satisfactorily, and a much higher level of skill is shown.

The record of writing progress in Figure 12 was for a child with an IQ of 130. A sampling of results for another child will be presented. This child had an IQ at the other end of the distribution (IQ 89). Nevertheless, the similarity in the course and form of the learning is quite evident. (The letter stimulus in response 5 is not seen, but it is a primary-sized a. In response 7, the b stimulus is also not seen, but was present for the child.) His response number 16 is his 929th learning trial in imitating and writing letters.

Place Figure 13 about here

The records for both of these children, and for the others as well, indicate that the acquisition of the letter imitation repertoire requires a number of learning trials and is a gradually acquired repertoire of imitation skills. The number of learning trials involved and the gradual increase in ability in this complex imitation skill distinctly suggest that imitation is not a basic given in the child, but consists of learned skills.

1



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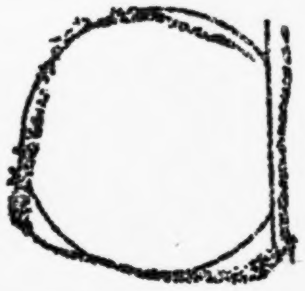

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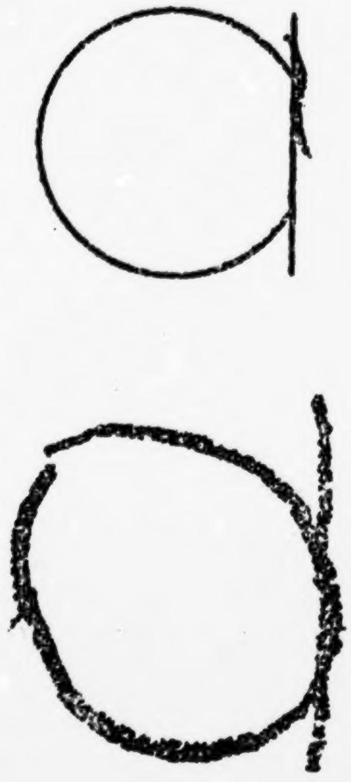

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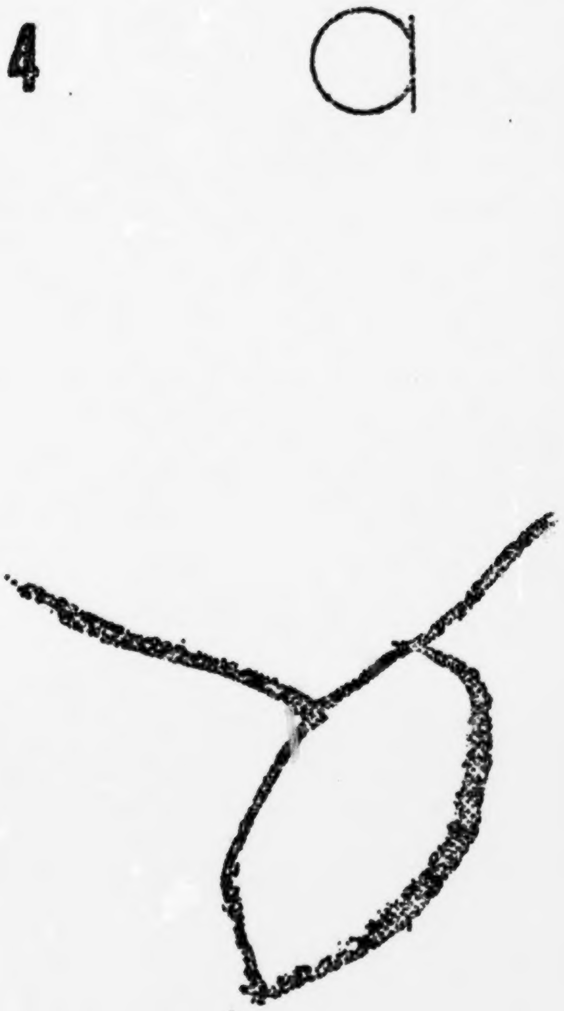

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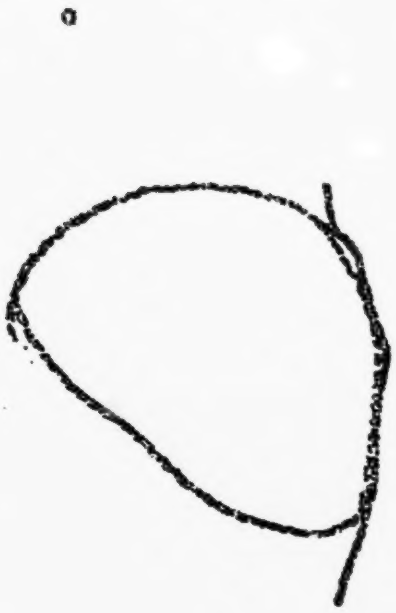

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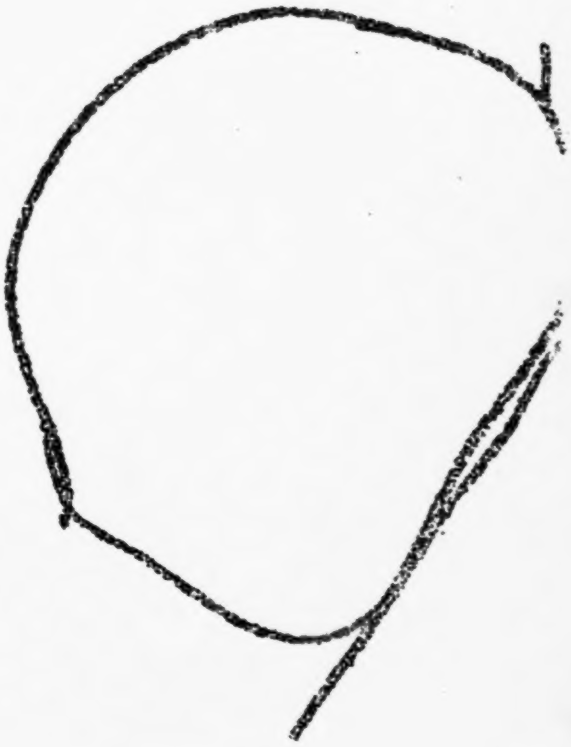

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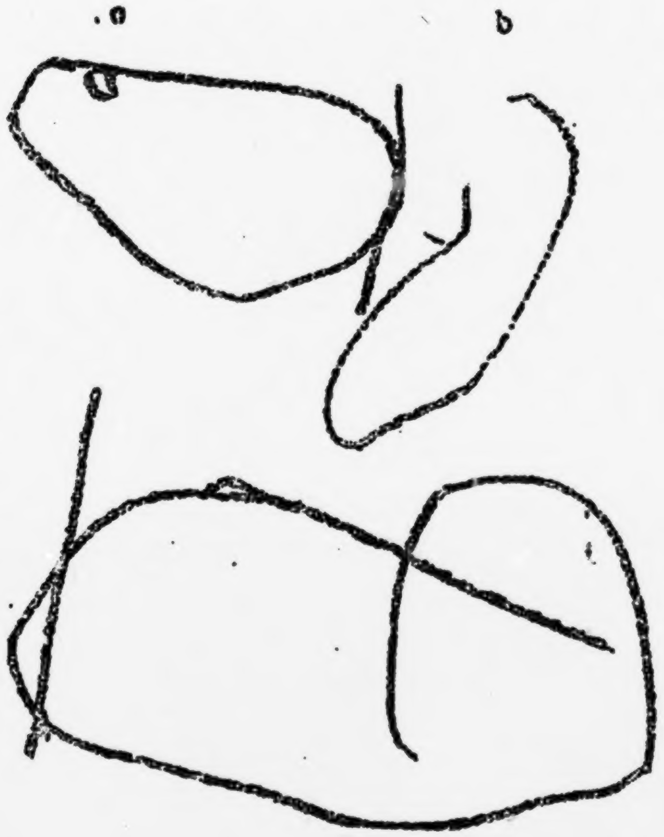

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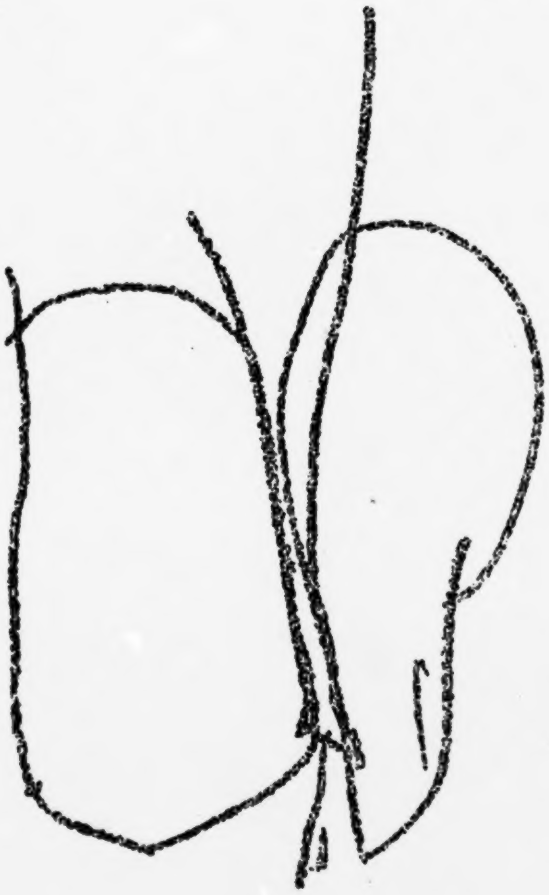

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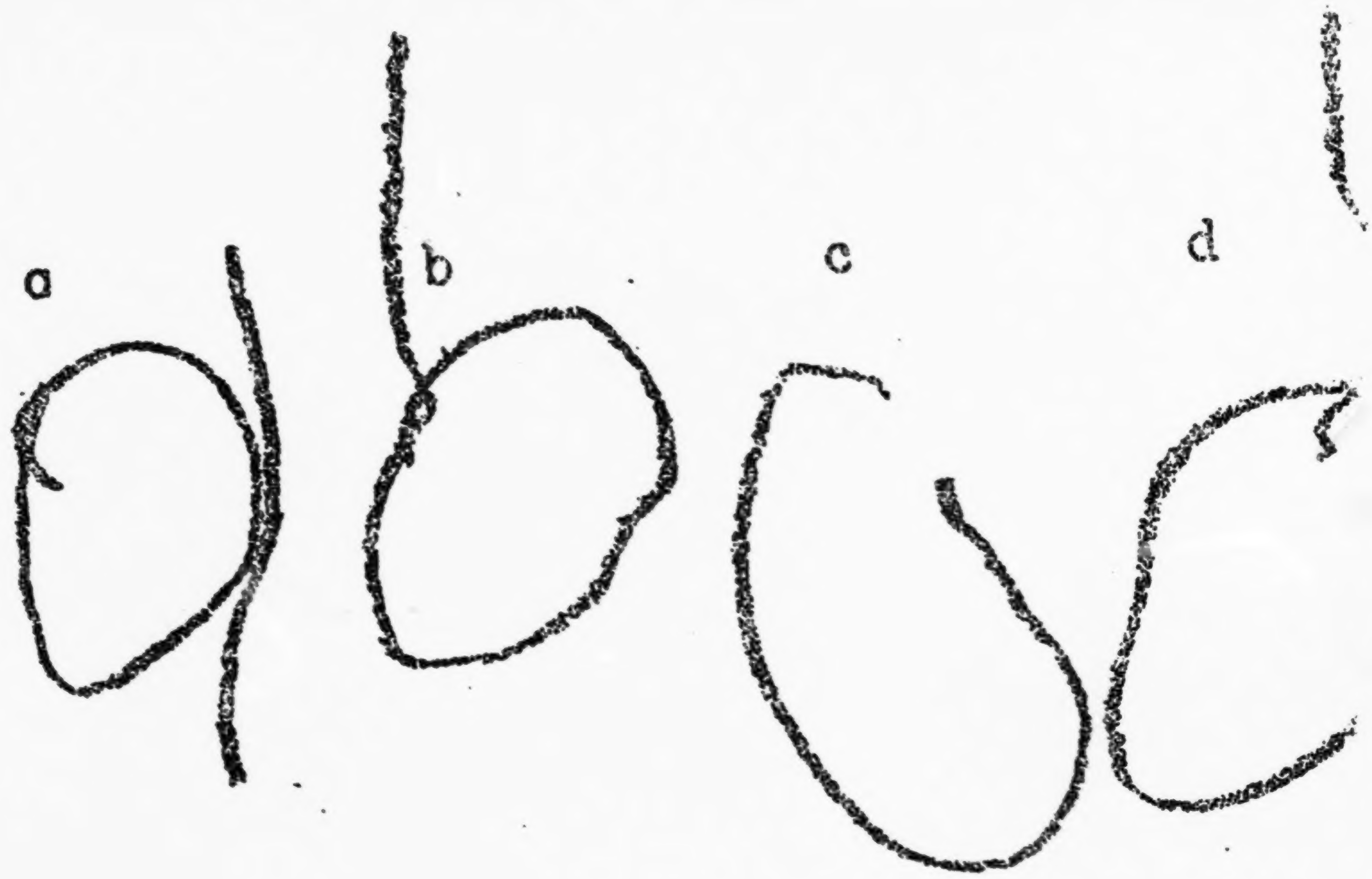

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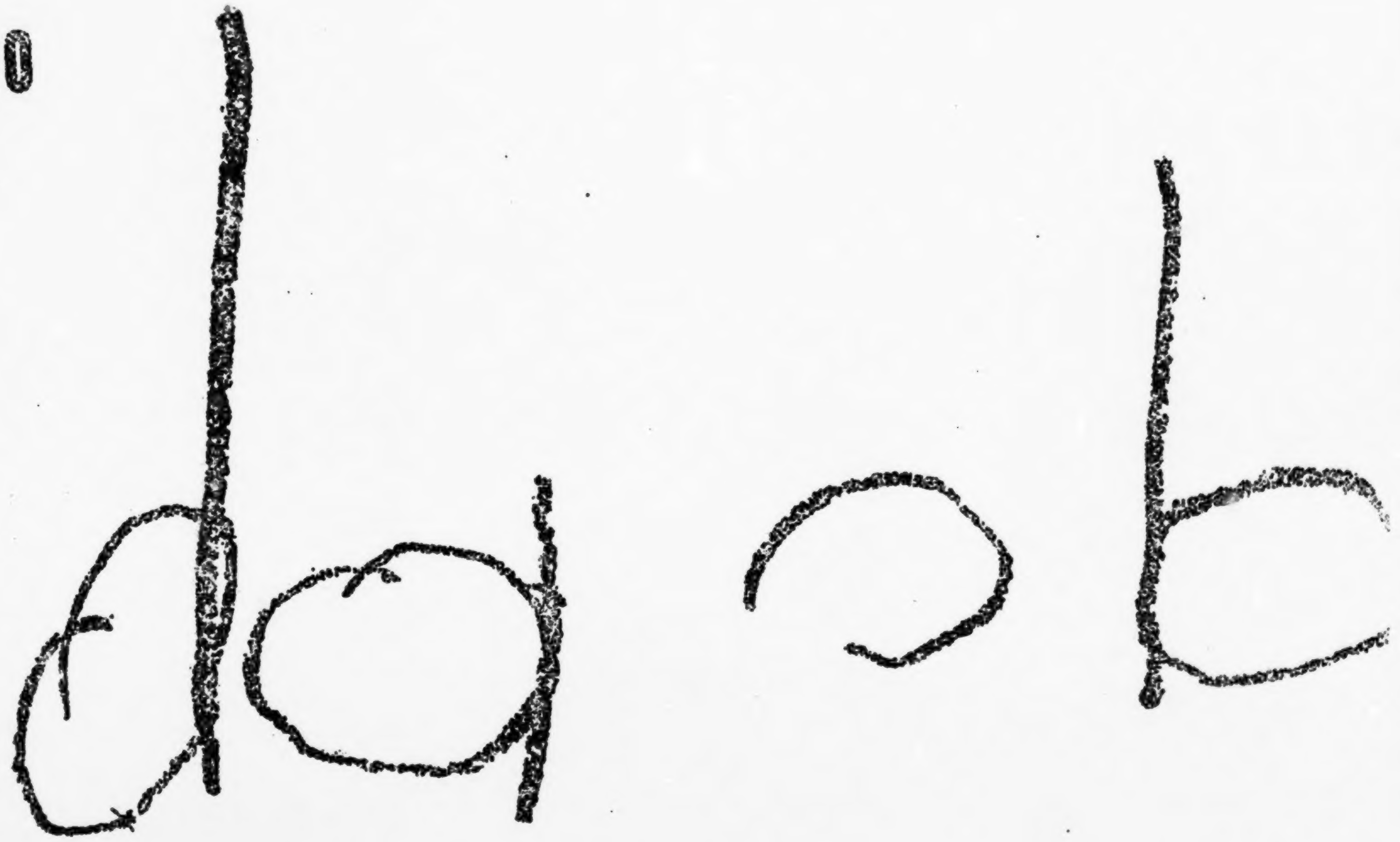


11

a b c d e f

a b c d e f

12*

a b c d

e f

13

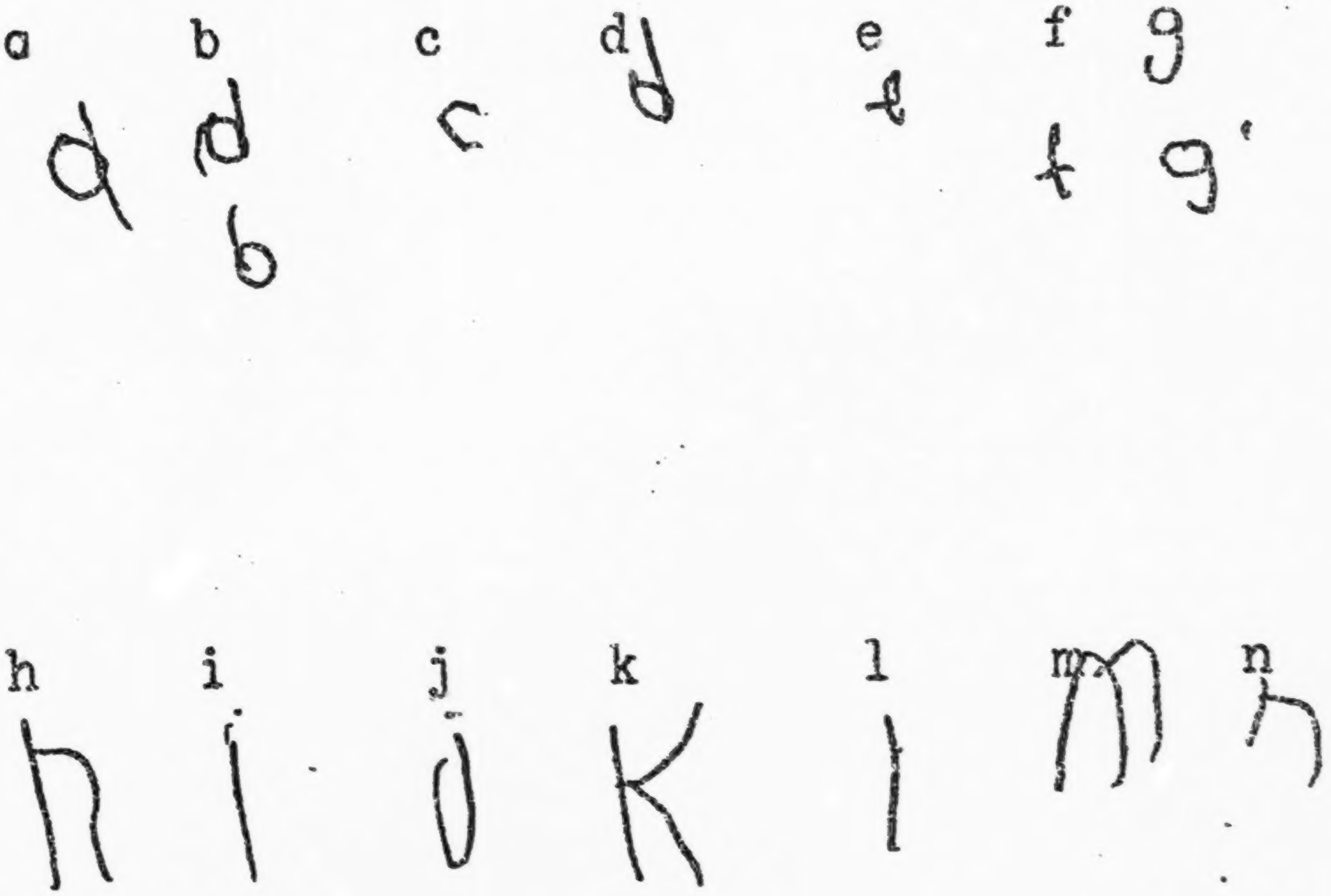
a b c d e f g h

abcdefgh

14

a b c de fgh

15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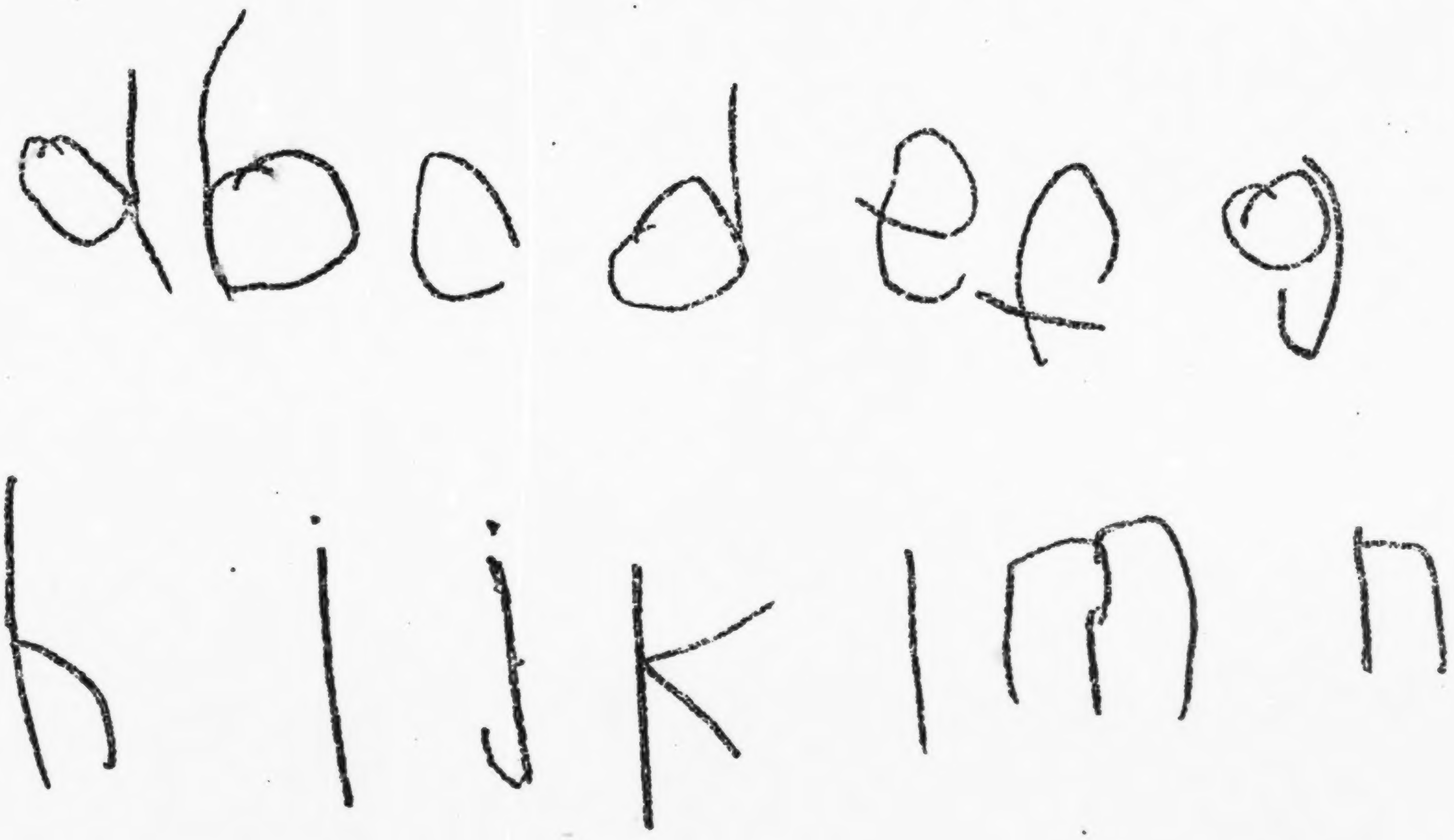
16


abcdefg
hijklmn

17

d b c d e f g

h i j k l m n

o p r s t

A final sample of the writing repertoires of each of the 12 children is given in Figure 14. The first sample shown is of a boy with an IQ of 88 who was given a different type of training than the rest since he needed additional training in tracing and copying. The fifth child also required this pre-letter-writing training. The second child had an IQ of 88, and the training required to produce that level of writing skill took 15 hours and 22 minutes. The same information is abbreviated for the other children as follows: Child 3, IQ 89, 17 hours and 18 minutes; Child 4, IQ 90, 15 hours and 9 minutes; Child 6, IQ 99, 14 hours, and 37 minutes; Child 7, IQ 100, 14 hours and 36 minutes; Child 8, IQ 104, 15 hours and 15 minutes; Child 9, IQ 105, 15 hours and 28 minutes; Child 10, IQ 108, 16 hours and 3 minutes; Child 11, IQ 117, 15 hours and 59 minutes; Child 12, IQ 130, 16 hours and 43 minutes.

Place Figure 14 about here

The mean number of training sessions in this study was 124.3. The mean number of responses made was 4,183.2. A mean of 1,703.6 reinforcers was given. The mean ratio of reinforcers to responses was 2.46. The children spent a mean of 16 hours and 26.7 minutes in this training. Thus, the mean length of training session was 7.9 minutes.

The second major area of the study concerned the form of the learning curve produced as the children learned to imitate and write the successively introduced letter stimuli. Since the various responses of the children to the stimuli presented to them were recorded, it is possible to tabulate the number of learning trials involved prior to the child's attaining skill that was considered sufficient to advance to the next letter. The course of the learning could thus be characterized. The learning curves

① a b

② a b c d e f g h i j K l

m n o p r s t u v

③ a b c d e f g h i j r

l m n o p r s t u

④ a bcdefghijklmno

r s t

⑤ a b c de

⑥ a bcde fghijklm

n o

⑦ abcdefghijKlm

nopr

⑧ abcdefghijklmn

o p r s t u

⑨ abcdefghi

jklmno

⑩ abcde f g hij klm l

o p p s t v u v w

⑪ abcjefghljklmno

prstuvwy

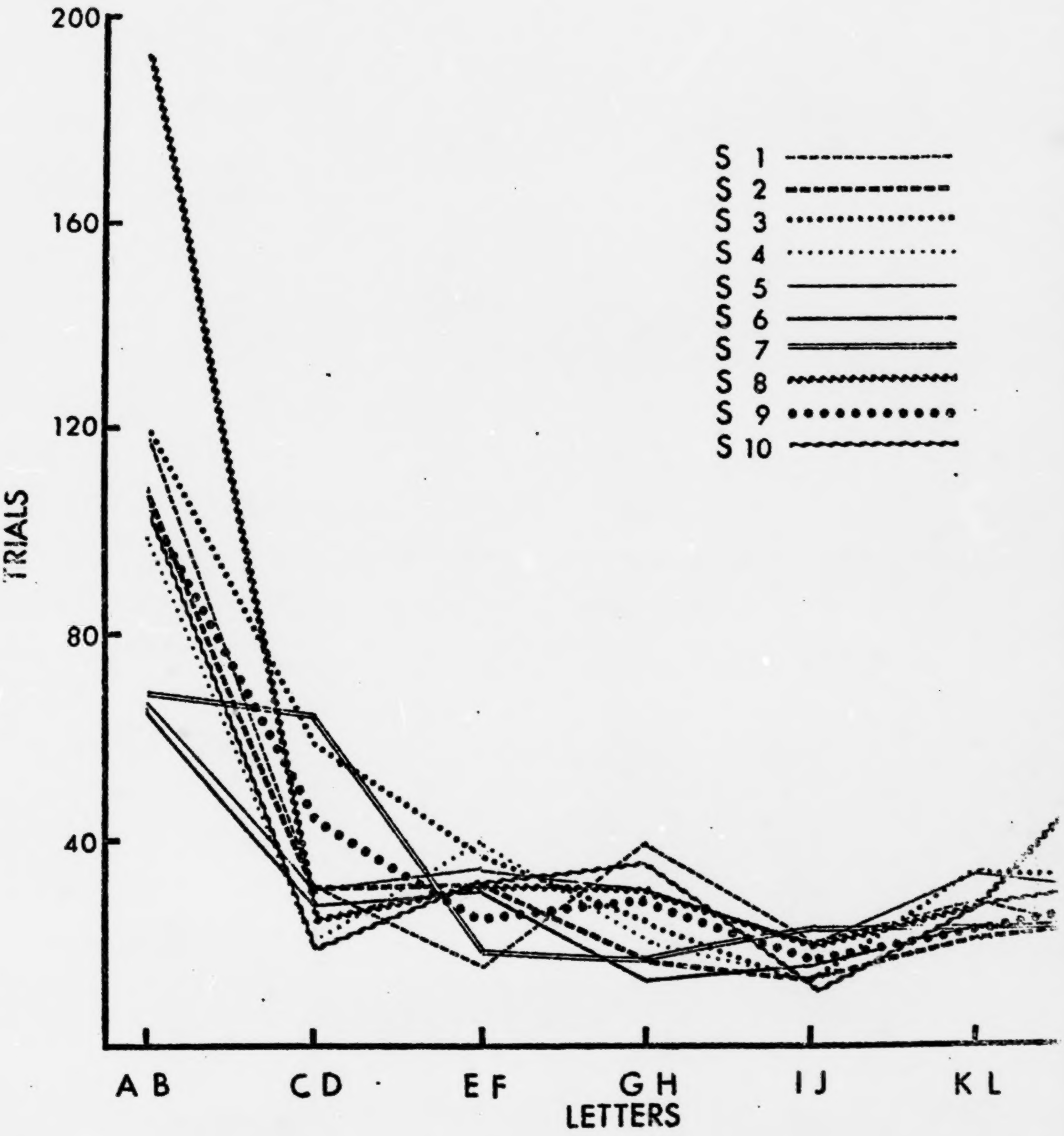
⑫ abcdefghijkl

mnoprstuvwy

for the 10 children who worked on the standard writing training described are shown in Figure 15. The curves are based on the results to the letter n, the last letter that all of the children completed. As can be seen, there is considerable homogeneity in the learning curves (across children who differed in IQ by as much as 41 points). This generality of response is shown by the shape of each curve, as well as the particular values (the number of learning trials involved).

Place Figure 15 about here

The learning curves again show very strongly the learning acceleration that has occurred in the alphabet-reading learning and, suggestively, in the number-concept learning. This learning acceleration occurred even though the criteria for having learned to imitate and write a letter well enough to progress to the next letter were progressively being raised. As the actual records of the children's writing show, the children were considered, in beginning this training, to have copied a letter sufficiently well to move on according to a much less stringent standard than was employed further on in training. It should also be noted that the entire learning curve is not included in the figure. Prior to the first learning trial involving the initial letter a, the children had received a large number of learning trials in tracing various kinds of lines. The mean number of such training trials for the 10 children was 176. This training, it would be expected, produced enhanced motor skills in the child, such as holding the pencil, as well as the initial sensory-motor imitation skills of drawing lines under the control of a visual stimulus. Without this prior training the learning acceleration shown in the figure probably would have begun at a higher point and dropped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S 7
S 8
S 9
S 10

more gradually. The form of the curve under such circumstances could be studied in future research.

At any rate, the mean learning curve for the group (shown in Figure 16) was subjected to statistical evaluation. The analysis of variance of the data is summarized in Table 14. As indicated, the differences between the mean numbers of trials to learn the letters are significant at better than the .01 level. A trend analysis of the curve was also completed and is summarized in Table 15. The linear downward trend of the learning trials necessary for learning the letters is significant at better than the .01 level. There is also a significant quadratic component to the curve (at better than the .01 level).

Place Tables 14 and 15 about here

Discussion

The results indicate that the complex imitation repertoire of copying letters, which is learned only over the course of a long-term period, may be acquired according to instrumental discrimination learning principles. The children were given training in which the stimuli were decreased in size, and they had to imitate longer series of stimulus letters to increasingly stringent standards of exactness. When the child engages in such an extended series of learning trials, his imitational skills become increasingly more precise--that is, his responses come to produce stimuli that match more and more the imitational or standard stimulus. It may be added that in this process the child learns not only specific skills--as in imitating the particular letters on which the child is trained. The specific training also yielded general skills of imitation writing. That is, there was an increase in the child's ability to copy a new letter when it was first presented.

Table 14

Analysis of Variance of Number of Trials Taken to Learn Successive Letters

Source	df	MS	F
Between Subjects	9	1,535.68	1.49
Within Subjects	60		
Letters	6	35,735.06	34.89**
Residual	54	1,024.26	

**p<.01

Table 15

Trend Analysis of Number of Trials Taken to Learn Successive Letters

Trend	F
Linear	90.59**
Quadratic	173.53**

**p<.01

The acquisition of the repertoire of writing skills showed an accelerating course of learning that was of the same sort demonstrated in the cognitive area of initial reading, as well as in the suggestive results in initial number concept development. Thus, it would seem that a preschool child, who has had even the relatively few total hours of training involved in the present study, would be learning material involving writing at a much faster rate than would a child of the same age who had not had the advantage of this type of training. The adult's general ability to imitate stimuli in writing would be expected to emerge from straightforward stimulus-response learning experiences of the type investigated in the present study. Other types of imitation skills that are important to child learning should be analyzed in S-R terms and their original acquisition studied.

The imitation writing repertoire is ordinarily considered to be a sensory-motor task, while learning to read is considered to be a cognitive task. Yet the same learning acceleration is shown in both types of learning. The generality of the phenomenon, which has considerable significance, as will be discussed later, is given support from the suggestive results with the number concept learning. Additional research in other areas of cognitive development should be conducted to ascertain how universal the learning acceleration phenomenon is and the extent to which the learning ability acquired in one area will generalize to another.

GENERAL DISCUSSION

In commencing this monograph it was suggested that the need for dealing with representative samples of some universe of human behaviors must be recognized--that much psychological research suffers from dealing with trivial experimental tasks that do not represent a universe of important human behavior. The introduction also suggested that it was possible to employ learning principles and experimental methods in studying significant types of human behavior. Several relevant points can be made on this topic within the context of the present line of research.

It should be noted that the present line of research has progressed from the development of functional training materials, based upon the S-R analyses and procedures, to the development of means by which explicit tests and study of learning principles could be achieved. This has constituted innovational work which has advanced only as knowledge was gained through the research program. The preceding account has recorded some of the steps made in this development--and on this basis additional research avenues and methodological developments may be projected. However, a moment should be spent in first indicating the functional value of the experience for the children in the study.

First, the behaviors dealt with herein were representative samples of functional behaviors ordinarily acquired by children at a later age than the preschool subjects of study. Although the three repertoires of behavior dealt with were treated only over a period of a school year, it was nevertheless possible in this time to provide the children with functional skills. The children who served as subjects acquired functional writing skills of an imitative type. These imitative skills were general in character, also. The children made progressive gains in imitating new letters on first presentation. Moreover, they learned to write the letters under the control of oral instructions and their own self-instructions. Children were also trained to discriminate functionally the numbers of objects and to count them. Some of the children who completed this task learned to read the numbers and also learned a part of the addition tables. In the area of reading, most of the children learned complete upper-and lower-case alphabets. Having the skills that go into reading the alphabet has been shown to be strongly correlated with the later development of reading. All of the children made important progress in acquiring the central letter-reading skills, and four of the 11 children had time to enter into extended training in the acquisition of letter-reading elements (grapheme-phoneme units). The children who had the advantage of this training all showed that they had learned reading units that generalized to new, novel combinations of letters. Thus, in this rudimentary form, they had learned to sound out new words--the essential constituent of "breaking the code" in learning to read. Such skills enable the child to learn to read through his own reading--not only through classroom training. In addition to these, other fundamental skills important to the child's general learning were acquired. The children progressed greatly in their attentional and discrimination abilities and their ability to work, and so on. Perhaps, however, the most important increase in the functional cognitive abilities of the children resided in the behavioral indications that their learning ability itself had been increased. This topic will be treated in more detail further on. However, it is relevant at this point to note that the children appeared to be learning at a more rapid rate in the reading, number, and writing areas after the training than they had at the beginning. Accelerating the children's learning rates in cognitive development may be considered to have vast functional properties.

The question of the usefulness of the experience for the children is an important one--for it is not possible to conduct a research program with children, in which they spend a good deal of time, unless it contributes to the child's welfare as well as to science. Thus, it is also relevant to indicate that in both the Wisconsin and Hawaii studies, the children were given standardized tests before and after the period of cognitive training and participation in the preschool. In the Wisconsin study, the children were tested four times on the Stanford-Binet (1937) and four times on the Metropolitan Readiness Tests,(1948). The mean IQ scores were 100.9, 106.3, 104.2, and 112.5. The four mean Metropolitan scores, with a norm group one to two years older than the children in the study, given in percentile scores, were 2.3, 4.5, 14.3, and 23.8. The number of times the children took the tests, however, may have had the effect of making them "test-wise," and may thus have contributed in part to the increase shown. In the Hawaii study, the tests--Stanford-Binet (1960), Metropolitan (1948), and Peabody Picture Vocabulary (1959)--were given only before the training and after the training. The Stanford-Binet pretraining scores had a mean of 105.4; the posttraining mean was 111.7. A correlated $\underline{t}$ ratio was computed for the difference between the means. The $\underline{t}$ was 1.51, which only attains the 0.10 level of significance. The mean scores for the Peabody were 91.6 and 98.7, which yielded a $\underline{t}$ of 1.31. The mean scores in percentiles for the Metropolitan were 5 and 19. The $\underline{t}$ for the difference between the means was 3.92, which is significant beyond the .01 level. Furthermore, in both the Wisconsin and Hawaii studies, the children's greatest improvement on the Metropolitan coincided with the areas in which they had been trained in cognitive skills--that is, those having to do with the alphabet, copying, and number skills,

Thus, in addition to the direct observation of the behavioral skills the children had gained, there was evidence of a gain in intellectual skills on the standardized tests. In the Wisconsin study, the children were all culturally deprived and would ordinarily be expected to show regressing scores over time. However, the extent to which the present type of training is superior to that provided by other types of preschool experience is certainly an open question (and one that should be the subject of research). The results do provide support along with the other evidence, that the children were benefiting from the experience, at the very least, to a standard degree. It may be concluded that the procedures and principles have value in producing learning in children that has functional value for them. Moreover, the materials have not been developed intensively for this purpose yet and it would seem that a great deal of additional progress in this regard would be possible.

The emphasis in this discussion has been on meeting the practical obligation to the child. In the research context, however, this is important because it enables the scientific investigator to study representative samples of behavior. The results suggest that it is no longer necessary to restrict study to experimental tasks whose relationships to any actual human behavior is unclear. Basic learning principles can be studied in the context of important, representative samples of human behavior. For example, it was shown that verbal response sequences (rote learning) could be experimentally produced and studied, and the effects of such sequences in cognitive behavior (number concepts) could also be investigated. Concept formation was studied in the context of reading. The sensory-motor skills of imitation were experimentally investigated in the realm of writing. The possibilities of doing this in other realms of behavior should be exploited. The attempts to do so, it is suggested, will help prevent the unguided nature and sterility of fields like verbal learning, where contact with any real human behavior was lost sight of many hundreds of experiments past. When there is no philosophy to advance the research in terms of improving the representative nature of its samples, the field takes on the inbred, out-of-contact, trivial character of the present-day verbal learning, concept formation, problem-solving endeavors.

The study of such representative samples, moreover, has the potential for yielding a full scientific conception of cognitive development. Psychology has to devise methods and facilities for the conduct of such research. The present study demonstrates the possibilities. However, much development remains. One of the important elements in studying representative samples of complex human behavior concerns the facilities and procedures by which to present and record conditions that produce behavioral changes over long periods of time. It is only possible in this way, to investigate, for example, the fully functional skills of an expert reader that begin with the acquisition of the necessary attentional and discrimination skills. These basic behavioral skills then form the basis for learning the alphabet discriminations; these then form the basis for learning the elementary reading units (grapheme-phoneme correspnndences). These in turn, form the basis of acquiring a large repertoire of word-reading responses, and so on. Such progressions in the successive and cumulative accretion of complex behavioral repertoires can only be investigated over the years necessary for these complex repertoires to be learned. One cannot get an idea of the tremendous importance of learning in the child's cognitive development until such long-term, cumulative types of learning are studied.

The present findings deal with the several areas of cognitive skill only through the first year of training. However, the prior experimental-naturalistic research conducted by the first author with his children indicates that fully functioning repertoires can be produced over the longer periods involved. For example, the stimulus-response training in reading can be continued until the child has fully developed reading skills, including the development of other, "intrinsic," sources of reinforcement for reading (see Staats, 1968_a_). At any rate, such long-term research must be conducted more systematically and formally. This will have to involve the study of children not only for one year, but for the additional time necessary to produce fully functional repertoires of skill. The suggestion that experimental-longitudinal research of this type can contribute to the child's benefit, while recording explicitly the stimulus-response elements of the training, provides a potential methodology for such long-term research. Again, it is important for psychology to begin the development of experimental facilities in school-laboratory complexes so that this type of experimental-longitudinal research can be conducted.

The development of the experimental-longitudinal research methods in the present realm of study may be described a bit more. In the introduction, the course of the extended project was mentioned. The project began with experimental-naturalistic study of a behavior modification variety. This included the development of the token-reinforcer system for long-term work with subjects, the principles and efficacy of which were tested in laboratory work. Also, more systematic long-term research, essentially of an experimental-naturalistic sort, was begun on single preschool children. In this work, methods for producing, recording, and studying the complex learning involved in reading acquisition, number concept formation, and writing were developed. Then more formal, single-subject experiments were begun (see Staats, 1968a) with several additional children. With the corroboration provided by this study, the next step was to extend the methods to a group of children, which was done in the Wisconsin and Hawaii studies. This involved the use of a laboratory-classroom complex where the children were totally under the administration of the research director. The recording of every stimulus and response produced a great wealth of data concerning the behavior of the children in the long-term learning process. Ways of organizing and evaluating the behavioral data then assumed a more important role in the research. Up until the present report, for example, no statistical analysis of such phenomena as the learning acceleration had been qualitatively observed. The present study thus represents the beginning of the fusion of the experimental-longitudinal research methods with statistical assessment of the results. The present study has been occupied with the behavioral data internal to the study, it should be noted. As the line of research with remedial reading showed, however, at a later stage the use of experimental and control groups and intergroup statistical comparisons can be usefully added. The later development of the experimental-longitudinal methods with other designs and methods of analysis holds forth increased possibilities for more generally assessing the effects of the experimental manipulations--without losing the detailed observation necessary to study the processes involved. Thus, it should be recognized that different methodologies may be appropriate at different stages of development of the experimental-longitudinal study of a complex human behavior. It is the general logic and technique of experimentation that must be applied to any particular problem. In the beginning, single subjects may be studied and their behavior recorded. Careful study of this type, explicitly derived from a stimulus-response analysis of the behavior, may yield reliable and general findings. Later, as advances in principles, procedures, and hypotheses in the area are obtained, the methods may be applied to groups and such research designs and methods of analysis may be added. Explicit recognition of the place of the beginning aspects of the research should be made, however, when the methods are still innovative, or such research will never be conducted. Few researchers are prepared to experiment for several years, obtaining valuable data, but without being able to publish for several years until they have advanced their procedures to the point where presently accepted methodologies become appropriate.

In this context it is important to note the very lawfulness of child learning--for this lawfulness makes it possible to establish general principles and procedures in studies of single children. Each of the procedures investigated herein, plus the remedial reading procedures described in the introduction, were worked out in experimental studies with single children. Although additional knowledge was obtained in working with additional children, the general methods, principles, procedures, and materials transferred very lawfully to additional children with widely ranging characteristics. In the present studies this lawfulness in learning was further demonstrated in each of the areas of cognitive skill.

This lawfulness in learning is important because there is a general conception that children learn in very diverse ways. It is commonly suggested that individual methods of training have to be devised for each child. The conception also enjoins one not to study child learning with the goal of discovering general laws. Although the present findings are by no means complete, the suggestion of the findings in these respects is quite clear. The possibilities of lawfulness in child learning must be opened for free investigation.

It may be noted in this discussion that the explicit and somewhat detailed analysis of the stimulus-response components of the behavior being studied constitutes an important part of the methodology. In each case, the research has been based upon such an analysis, and has sprung from the analysis. Hence, it is relevant to indicate that when one makes an analysis of a type of human behavior in terms of S-R mechanisms and learning principles, the analysis constitutes an explanatory theory of that type of behavior. That is, the principles involved are "cause and effect" principles that state that if such and such is done, it will produce such and such effects upon the behavior. Moreover, from the general theoretical body, one can derive additional hypotheses. For example, the analysis of the repertoire of counting skills in specific S-R terms and instrumental learning conditions constituted a theory of that type of behavior. On the basis of the theory it was possible to present stimuli to children based upon the S-R analysis, within the context of instrumental conditioning procedures, and produce the complex skills of counting. Moreover, it was possible to derive from the theoretical body the hypothesis that the total repertoire of skills could be advanced--after the children had learned the basic repertoire--by simply extending the verbal response sequences further in rote learning procedures. This hypothesis, and thus the larger theoretical body, was tested, with explicit experimental results. The general aspects of this methodology and its possible extensions should be realized.

While the main purposes of the present study were of a research-theoretical nature, the relevance of the methods, principles, and results of the study for actually dealing with problems of children's learning cannot be overlooked. The present methods have shown possibilities for contributing to the actual learning of very young children in various kinds of situations. The results indicate that very young children can be given cognitive training in which they participate voluntarily and in which they can acquire important cognitive repertoires. They also indicate that this is fairly universal across different children with different types of problems (Staats, 1968a). One of the most severe penalties for children with problems of behavior, and one that has not been stressed sufficiently, involves the interference with cognitive learning that results. "Underachievement in school is the single most common characteristic of emotionally disturbed children" (Hobbs, 1967, p.1110). If the cognitive learning is not maintained throughout childhood, the child will be unable to adjust, even if his other "emotional" problems are solved. Included in both the Wisconsin and Hawaii studies were children who had severe problems and yet who learned well in the training procedures employed. These and the general findings encourage the wider employment of the approach in treating children with problems at an early age. This should be done so that the children do not develop deficits in behavior that will make appropriate later adjustment difficult or impossible.

In the various studies herein, as well as in the preceding studies, the procedures were effective in producing and maintaining attention and good work habits over long periods of time. This is ordinarily difficult to produce with the child who has problems or with the young child. Of special significance, also, was the fact that it did not require long daily periods, or a large contribution in total time, to produce a very large number of training trials. Unlike the methods of traditional learning situations, including the school, the present methods make it possible to get a large number of learning responses out of the child in brief periods. When children attend well, have few irrelevant or disrupting behaviors, and make responses rapidly, not much total time is involved. This fact yields various possibilities for more effective training of children. For example, Staats (1968) has noted that the school has long classroom hours in part because the rate of presentation of learning trials is low. Methods that produced a greatly increased rate of learning trial occurrence could suggest general school reorganizations.

Moreover, the ability to conduct many learning trials in brief periods makes it possible to employ the methods in the home. Few parents can afford to spend long daily periods of time with their children to insure their later success in school. However, a large number of parents would be very willing to spend three to five minutes a day with their children to provide them with learning skills that would insure that they would be enabled to learn well in school. Additional studies should be conducted to demonstrate further the feasibility of parents employing the present approach in training their own children in cognitive skills. This type of study has already been conducted with the remedial reading methods described in the introduction (Ryback and Staats, in preparation).

In reporting the preceding experimental results, some special attention was given to the acceleration of learning phenomenon. This was done in part because of the significance that the concept has for general conceptions of child development. That is, a very dominant conceptual tradition in child and developmental psychology has been that the behavioral development of the child occurs to a large degree on the basis of biological development. This conception underlies longitudinal research which makes observations only on behavior plotted against an abscissa of time, which serves as the independent variable. Learning experiences that might contribute to the child's behavior development are ordinarily not considered. (We have a modern incarnation of this method and conception in the observations of language development of children by the new psycholinguists, without regard to the learning conditions that might produce that development. See Smith and Miller, 1967, for examples of this approach, and Staats, in press a for a criticism of the approach in learning terms.) Time is considered significant on its own in such studies because of the inference that it is (at least primarily) biological unfolding that is focally important in behavioral development.

The concept of readiness through maturation is another case in point. This general philosophy has in many cases involved a distrust of learning principles and explicit training procedures. The child is thought to be better off if allowed to follow his own biological development, without being pressed through training to develop behaviorally. It has many times been stated that premature training for the child may be at best wasteful and quite likely harmful. There is, of course, an interactionist philosophy which recognizes, in name, the importance of learning, but which in actuality continues the rejection of learning by explicit failure to investigate learning variables and conditions in behavior development. The maturation-biological-developmental philosophy has widely permeated education, it may be added, where it has many manifestations and many implications.

If, however, as the present approach would suggest, behavior development of the child comes about largely or entirely through learning, then we are following an incorrect approach and are employing a philosophy that has many implications for social decisions that should be challenged. It is in this context that the present results, in general, should be considered. The various results suggest that children learn their cognitive skills through explicit experience. It also appears that children are prepared to receive explicit cognitive training and benefit from it at an earlier age than has been generally thought. These suggestions emerge from the various studies of the series (Staats, 1968a; Staats, Finley, Minke, Wolf, and Brooks, 1964; Staats, Minke, Finley, and Brooks, 1964; Staats, Staats, Schutz, and Wolf, 1962), not only the present study. The results are consonant with the conception that children do not acquire complex cognitive skills through maturation but through experiential conditions, and on the basis of known learning principles.

The results suggest not only that young children can be presented with systematic training to their benefit, but also that the process has even more general advantages. The results show that children learn not only specific skills when subjected to this type of training, but also become better able to learn additional cognitive skills. The present findings must be considered only as first steps in the investigation of the extent to which learning acceleration occurs in child development through learning experiences. Additional study should be made of the generality of the learning acceleration phenomenon. It would be important to know if the training on the alphabet, for example, would accelerate the rate of acquisition of number discriminations, or some other type of cognitive learning and if cumulative learning accelerations can occur and have important effects. For example, having been trained in the alphabet task, would the child show a more rapid learning acceleration on the concept formation task than a child not previously trained?

Furthermore, and perhaps of most immediate importance, over what range of types of learning does the learning acceleration phenomenon occur? This acceleration was shown in the alphabet learning task, writing task, and, to some extent, in the number concept learning task. Additional areas should be studied, for example, in learning concepts of size, shape, color, and so on, and in later cognitive skills developed by children.

Although the findings suggest additional areas of study, they themselves may at this point be considered to be a challenge to the maturation-readiness types of conception. It appeared in the several areas dealt with that the child came to learn better as he learned more. There was evidence that children who began learning at a somewhat slower pace than the others would learn as rapidly after their learning acceleration had been produced. There is further support for this finding. Staats (1968a) reports results for a three-year-old child as compared to two five-year-olds in terms of learning rate . The three-year-old required more trials to learn the same material at the beginning of training, but after about nine hours of training, he was learning at a greater rate than the five-year-old children had when they commenced training. In the brief period of training, the younger child had been turned into as good a learner as older children. A conception that learning rate is a function of the personal quality of the child would not predict such findings.

Intelligence is widely interpreted to reflect the individual's personal learning ability, or to reflect individual differences in learning rate. Thus, the suggestion that children's learning rate depends upon their prior history of cognitive training has considerable significance--it suggests that the ability to learn is determined by learning itself. Such findings, if suitably corroborated and extended, would be strong indication for a change in conception from the static biological conceptions of intelligence that presently flourish to a dynamic conception of intelligence as learned. As has been indicated (Staats, 1968_a_ in press _a_), biological conceptions have not yet shown direct evidence of biological variations that produce differences in intelligent behavior--except for a few cases of abnormality. The conception is based mostly upon indirect evidence and inference. If learning can have the effects suggested herein, it is premature to posit biological group differences in intelligence behavior (see Jensen, 1969), and it is time to begin the extensive study of intellectual development through learning.

Thus, the present evidence, by itself, speaks in favor of early cognitive training, and against the passive approach to child rearing suggested by the maturational unfolding conception of child development. It may be added that it is time to ask generally when and by what principles children can acquire the complex repertoires of skills that go into being accomplished human beings. Moreover, what these skills are must be analyzed into their behavioral components. The present findings suggest that when the behaviors are subject to analysis in terms of their stimulus-response components and into the learning principles involved, it is possible to begin experimental-longitudinal study of the acquisition of the behaviors. We need additional studies that treat important, functional, representative samples of behavior with such theoretical and experimental methods.

It should be noted, finally, that the present research did not begin with set guidelines to follow. The nature of the study precluded the use of known research designs and research methodology. There were no reinforcer systems, for example, for working over long periods of time with any subjects--not to mention with preschool children. The experimental training procedures had to be developed de novo, as did the training materials derived from the S-R analyses. No existing analyses concerning the learning of complex behaviors could serve as experimental hypotheses in any formal sense. There were no elements with which to attempt traditional hypothesis testing. And experimental and control group designs were irrelevant.

At the present point, however, the findings begin to indicate directions the research should take in terms of hypotheses and in terms of utilizing traditional experimental designs in further methodological development. Although the present line of research can only be considered to have been initiated at this point, the progress represents a great deal of arduous development; conceptions and methods have begun to form in the work, and the findings suggest a fertile area of future research.

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Footnotes

[1] The present monograph is the end product of almost a decade of research during which the first author developed the principles, materials, apparatus, and training procedures. The specific data which the monograph reports came from two sources. Part of the data were obtained by the first author in a year-long project supported by the University of Wisconsin Research and Development Center for Cognitive Learning (Contract OE 5-10-154). The remainder comes from his Child Learning Laboratory at the University of Hawaii in research supported by the Headstart Research and Evaluation Center (Contract No. OEO 4218), the Educational Research and Development Center, and the Department of Psychology. The Hawaii data collection occurred over an academic year period, and the second and third authors were research assistants on this project. The second author then spent an additional 9 months, supported by the Educational Research and Development Center, collating much of the voluminous Hawaii data and devising methods for its statistical analysis and graphic presentation. A description of these procedures and results materials constituted a part of her doctoral dissertation at the University of Hawaii in 1969. Portions of these procedures and results materials have been utilized by the first author in writing the present monograph, and he has used the general methods to analyze some of the additional data presented. The Wisconsin data, which had been previously obtained, and the additional Hawaii data, were collated and analyzed with the help of the second and third authors. Appreciation is expressed to Arthur King, Director of the Hawaiian Curriculum Center and to Hannah Lou Bennett

respectively for providing the facilities for the research and for help in securing the teacher and aids for the preschool classroom; and to Leonard Rush for cooperation in providing the laboratory-classroom complex for the research conducted in Franklin School in Madison, Wisconsin.

[2] John Carlson and the first author are presently testing this principle of higher-order instrumental conditioning with animal subjects.

Figure Captions

Figure 1. The Staats child learning apparatus.

Figure 2. Mean trials taken to read letters.

Figure 3. Mean trials for reading letters.

Figure 4. Time taken for alphabet reading.

Figure 5. Mean time to read letters.

Figure 6. Reinforcers required for reading letters.

Figure 7. Mean reinforcers for reading letters.

Figure 8. Mean alphabet reading response rate in trials per minute over 10 session blocks.

Figure 9. Reading concept formation.

Figure 10. The stimulus-response elements involved in learning to count a randomly arranged group of objects. From Staats, A. W. *Learning, Language, and Cognition*, New York: Holt, Rinehart and Winston, 1968, by permission of the publisher.

Figure 11. Trials taken for counting numbers.

Figure 12. Summary of the writing learning for a four-year-old child with an IQ of 130.

Figure 13. Summary of writing learning of a four-year-old child with an IQ of 89.

Figure 14. Writing skill samples of the 12 four-year-old children after training.